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EVALUATION OF THE TENNESSEE WATER SUPPLY PROGRAM

Bureau of Water Hygiene
Atlanta, Georgia

January 1971

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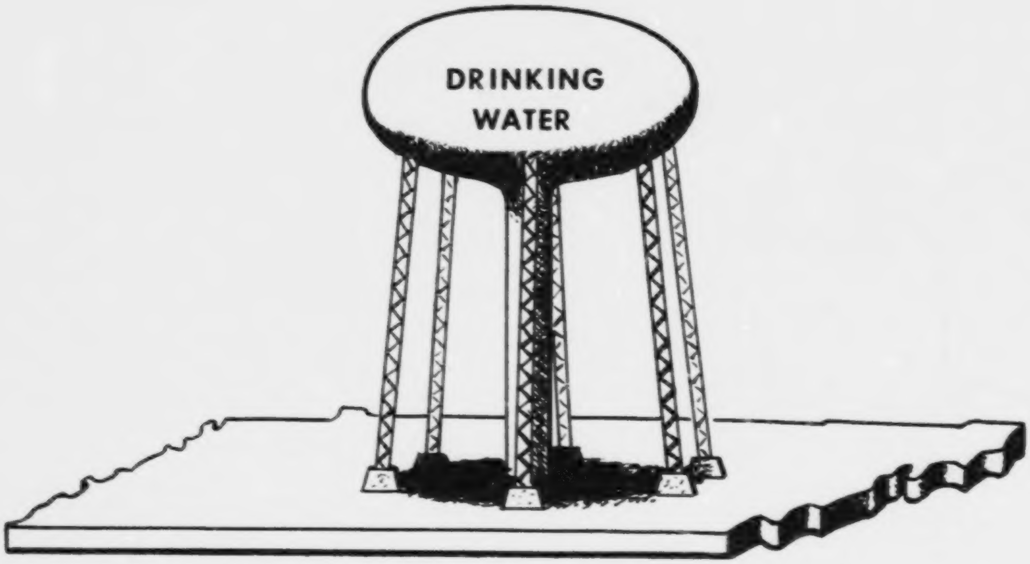

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Bureau of Water Hygiene

Environmental Protection Agency

Region IV

January 1971

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EVALUATION
OF THE
TENNESSEE WATER SUPPLY PROGRAM

BUREAU OF WATER HYGIENE

ENVIRONMENTAL PROTECTION AGENCY

REGION IV

JANUARY 1971

PREFACE

This report presents the Bureau of Water Hygiene's findings, conclusions and recommendations, with supporting data and explanatory text of the study of the Tennessee drinking water supply program.

The information contained herein has been condensed and the significance of the findings is further discussed in a companion report EVALUATION OF THE TENNESSEE WATER SUPPLY PROGRAM - SUMMARY. The SUMMARY highlights important results and areas of major need for all those who have an interest in Tennessee's drinking water but who do not wish to study the numerous details of the complete report.

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SUMMARY OF FINDINGS AND CONCLUSIONS

Recognizing that the health of over 3.9 million people in Tennessee is directly dependent upon the condition of their drinking water, Dr. Eugene W. Fowinkle, Commissioner, Tennessee Department of Public Health, requested that the Bureau of Water Hygiene evaluate the Department's Water Supply Program. This report presents the Bureau of Water Hygiene's findings, conclusions and recommendations, with supporting data and explanatory text of that evaluation.

Approximately 3 million people in Tennessee are served by 445 public water systems. Another 900,000 rural residents obtain their drinking water from individual water systems. In addition, there are about 800 "semi-public" systems at restaurants, service stations, recreational facilities, amusement parks, etc. and as many as 3.8 million residents and traveling public may be exposed to this water at one time or another during a year's time.

The effectiveness of the Tennessee Water Supply Program was judged primarily on the bases of drinking water quality, adequacy and condition of water system facilities, and water supply surveillance. Thirty-nine (39) public, 64 "semi-public" and 571 rural, individual water supplies, representing a cross-section of water supply practice in Tennessee, were selected for study. These systems serve over 50 per cent of the State's population.

The principal findings and conclusions of the study are:

WATER SUPPLY STATUS

Water Quality-Bacteriological

Thirty-one (31) per cent of the public water systems examined did not meet bacteriological standards one or more of the past 12 months. These systems serve approximately 28,730 people.

Fifty-nine (59) per cent of the rural, individual supplies examined failed to meet bacteriological standards and fecal contamination was confirmed in three-fourths of these cases. These systems serve approximately 1,680 people.

Nineteen (19) per cent of the "semi-public" systems examined failed to meet bacteriological standards and fecal contamination was confirmed in three-fourths of these cases. It is estimated that as many as 41,070 people (State residents and the traveling public) may be exposed to this water during one year's time.

Water Quality-Chemical

Five (5) per cent of the public water systems examined did not meet mandatory chemical drinking water standards. These systems serve approximately 179,800 people.

Two (2) per cent of the rural, individual water supplies examined failed to meet one or more mandatory chemical drinking water standards. These supplies serve approximately 57 people.

Thirty-three (33) per cent of the public water systems examined did not meet one or more of the chemical drinking water standards. These systems serve approximately 926,500 people with less than desirable or aesthetically inferior drinking water.

Twenty-six (26) per cent of the rural, individual water systems failed to meet one or more of the recommended chemical standards. These systems serve approximately 740 people.

Thirteen (13) per cent of the "semi-public" systems were judged to provide aesthetically undesirable water. As many as 189,736 people (State residents and the traveling public) may be exposed to this water during one year's time.

Facilities

Sixty-seven (67) per cent of the public water systems needed additional treatment facilities and 62 per cent needed important changes in the operation of present facilities. Without these additions and changes, continuous protection of safe drinking water may not be maintained.

None of the 24 public water supply fluoridation programs evaluated were fully acceptable. Only 50 per cent of the systems were fluoridating at the proper level, thus significantly reducing dental health benefits.

Thirty (30) per cent of the public supplies and 46 per cent of the "semi-public" supplies examined which chlorinate did not provide a detectable chlorine residual in all parts of the distribution system. Unsatisfactory chlorination practice removes the margin of safety against disease transmission through drinking water.

Twenty-eight (28) per cent of the public water systems examined had inadequate distribution system storage and 21 per cent had inadequate water pressures in some or all areas of the distribution system. Seventy-two (72) per cent had inadequate cross-connection control programs. Flawless treatment avails nothing if the distribution system does not deliver adequate water for essential health needs or permits entrance of hazardous substances through cross-connections or other system deficiencies.

Eighty-four (84) per cent of the "semi-public systems rated overall less than "satisfactory" and 66 per cent needed additional treatment. Nine (9) per cent had visible sanitary defects, which clearly present the potential for dangerous contamination.

Nearly every one of the rural, individual systems examined had one or more facility deficiencies. Very few of these systems were constructed to prevent entrance of contamination.

Operator Competence

Thirty-one (31) per cent of the public water supplies examined were maintaining inadequate operational records.

Thirty-six (36) per cent of the public water systems evaluated had only part-time operators and 33 per cent of public water supply operators were not certified by the Tennessee Department of Public Health. Most of these systems also had water quality problems and/or facilities deficiencies.

Surveillance

Fifty-four (54) per cent of the public water systems evaluated did not meet bacteriological surveillance standards and 80 per cent had not had a chemical evaluation during the past three years. Forty-one (41) per cent had not been rated by a representative of the Tennessee Department of Public Health during the previous twelve months. Without health agency surveillance, hazardous conditions will persist undetected and uncorrected.

Seventeen (17) per cent of the "semi-public" water systems evaluated had not had a health agency visit in the previous two years. These visits do not include a full inspection of facilities and operational practices.

WATER SUPPLY PROGRAM

The funds expended for drinking water protection in Tennessee are totally inadequate to support a comprehensive program. The Division of Sanitary Engineering administers the program with a budget of only $69,500. Even taking into consideration laboratory support provided by other programs, less than 3-1/3 cents per capita per year is spent to protect drinking water.

Staff limitations have prevented the Water Supply Program from fulfilling its responsibilities. Evaluation of Tennessee water supply practice indicates many supplies are deficient and present a high risk to the public. Due to the fact that only 3-1/2 man years of Professional Staff time is available, important Water Supply Program activities are not being performed or are being performed only in a cursory manner seriously reducing the effectiveness of the program. A Water Supply Program conducted in this manner creates a false sense of security.

The Department of Public Health has been reluctant to issue compliance orders for correction of water supply system deficiencies when such deficiencies were found a menace to public health. The penalty for violating the water supply code is insufficient.

Current Water Supply Regulations were issued by the Tennessee Department of Public Health in 1945 and have not been updated since, except for a special fluoride provision which was added in 1963. Raw and finished water standards for bacteriological, chemical, and physical drinking water quality are not specified in the regulations. No provision is made for the orderly development of new public water supplies nor are the general types of water systems which constitute a public supply defined.

The Division of Sanitary Engineering's water supply policy is contained in a number of publications and documents. The lack of a single, complete policy document has caused problems for water supply program staff and waterworks officials, alike.

Eighty-five (85) public water systems perform their own bacteriological analyses. Only seven of these laboratories have been certified by the Department of Public Health. Review of noncertified laboratories revealed unacceptable laboratory procedures. These laboratories have created a false sense of security and the effectiveness of overall operational vigilance has been reduced as a result.

Operator training activities have reached a majority of the public water supply operators. Nevertheless, system and operational deficiencies indicate that recommended waterworks practice and public health protection are not being universally applied.

An immense quantity of data must be accumulated, processed and analyzed for the successful management of a water supply program. This important activity, now being done entirely by "hand" and consequently too time consuming for experienced professional personnel, is seldom given proper attention.

The Division of Sanitary Engineering, Tennessee Department of Public Health, administers the State's Public Water Supply Program. However, the Tennessee Camp Sanitation Act administered by the Department's Division of Environmental Sanitation and the Tennessee Department of Conservation's Divisions of Water Resources, and Hotel and Restaurant Inspection have water supply responsibilities which parallel and somewhat duplicate those delegated to the Division of Sanitary Engineering.

* * * * *

In summary, the Tennessee Water Supply Program is not providing the health evaluation and engineering services necessary to fulfill its responsibilities to protect the health of the citizens of Tennessee. To properly provide such services, the following recommendations are made.

RECOMMENDATIONS

It is recommended that:

1. The Water Supply Program be elevated to full Division status in the Bureau of Environmental Health Services with a minimum annual budget of $510,000. These funds should be used for:

a.	Water Supply Activities	$384,000
b.	Laboratory Services	126,000
	Total	$510,000

2. The Division of Water Supply be initially staffed with a minimum of 11 professionals, 4 sub-professionals and 7 secretaries.

3. Water Supply activities be further decentralized by assignment of an Assistant Director and staff of five to the Knoxville Regional Office and establishment of a new Jackson Regional Office with an Assistant Director and staff of two.

4. Two bacteriologists and one secretary be hired by the Division of Water Supply and assigned to the Division of Laboratories for certification of water laboratories. Similarly, three chemists and one secretary be hired and assigned to the Division of Stream Pollution Control Laboratory for drinking water chemical analyses.

5. The Water Supply Regulations be revised and expanded to more comprehensively reflect current recommended water supply practice. The following specific features should be included:
    a. Quality standards for raw and finished drinking water.
    b. Mandatory disinfection of all water systems serving the public.
    c. Mandatory certification of all public water supply operators.
    d. All water systems serving the public be designated a "Public Water Supply" subject to all regulations pertaining thereto.
    e. Provide for orderly development of new supplies.
    f Require that water system plans and specifications be prepared by registered professional engineers.
    g. Require that an individual or group be designated legally responsible for each Public Water Supply.

6. A single document be prepared and distributed which presents all current Tennessee Water Supply Program Policy. Provision should be made for updating this document as policy revisions occur.

7. The Division of Water Supply increase and improve its surveillance of Drinking Water Supplies to at least the minimum levels set forth in the Public Health Service Drinking Water Standards and Manual for Evaluating Public Water Supplies. These activities should include, but not necessarily be limited to:

    a. Thorough periodic sanitary surveys of each system, setting priorities and time schedules for improving those systems having deficiencies.

    b. Bacteriological surveillance sufficient to check laboratory analyses provided by the larger public water supplies, and in the case of small systems without laboratories, bacteriological surveillance sufficient to meet recommended Standards.

    c. Complete routine chemical analyses of all drinking water.

8. All water plant laboratories be certified by the Tennessee Department of Public Health as to their capability of performing "official" bacteriological analyses.

9. Automatic data processing techniques be employed for storage, analysis, and retrieval of water supply data.

10. Provision be made for close coordination between the Division of Water Supply and other State governmental functions which may affect water supplies. These include:
    - a. The Division of Water Resources and the Division of Hotel and Restaurant Inspection, Department of Conservation.
    - b. Other Divisions of the Environmental Health Services.
    - c. Local health departments.

Regulations of other State agencies should reflect that principal authority for regulation of public water supplies rests with the Division of Water Supply.

INTRODUCTION

This Evaluation was conducted to determine the effectiveness of the Tennessee Water Supply Program, and if necessary, to recommend such improvements as may be needed to assure safe, wholesome drinking water for the residents of Tennessee.

The study was undertaken by the Bureau of Water Hygiene, Environmental Protection Agency, at the request of Dr. Eugene V. Fowinkle, Commissioner, Tennessee Department of Public Health, who recognized the importance of water supplies to public health and suggested that such an evaluation would render a useful service to the Department.

BACKGROUND

State Board of Health concern about public water supplies can be traced back to an 1884 committee appointed by the Board to investigate water supplies. A continuous water supply program began in 1919 with a Public Health Service Engineer on detail to Tennessee and acting as State Sanitary Engineer. In 1921 the State General Assembly established the Division of Sanitary Engineering for water supply and sewerage control. The number of people served by public water supplies multiplied in the ensuing years, and in 1945 the present Water Supply Code was adopted, which gave the Division legal authority to conduct a water supply supervision program. While other environmental health functions have been added to and removed from the Division through several reorganizations, the Water

Supply Program has remained. The latest reorganization, effective July 1, 1968, created the Bureau of Environmental Health Services with Sanitary Engineering one of its five Divisions.

PURPOSE OF EVALUATION

Specifically, this evaluation attempted:

1. To ascertain the present condition of Tennessee's water supplies through inspections of treatment plants and distribution systems; bacteriological, chemical, and radiochemical laboratory analyses of water samples; and, examination of pertinent data recorded in Department of Public Health files.
2. To determine the adequacy of legal statutes, budget, manpower resources, regulations and policies, laboratory support, surveillance, and operator training.
3. To review the effectiveness of the Water Supply Program in the light of the present condition of the State's water supplies, and to make recommendations as to what additions and revisions should be made to assure adequate health protection for the drinking water supplies of Tennessee.

SCOPE

WATER SUPPLIES IN TENNESSEE

According to the 1970 census, 3,924,164 people reside in Tennessee. About 3 million of these people are served by 445 public water supplies. Many of the remaining 924,164 people live in rural areas and obtain their drinking water from individual water systems. In addition to the public supplies, there are an estimated 800 water systems generally known as "semi-public" which may serve as many as 3.8 million residents and traveling public at restaurants, service stations, recreational facilities, amusement parks, trailer courts, and other similar establishments.

WATER SUPPLIES STUDIED

In discussion with Mr. James L. Church, Jr., Assistant Commissioner for Environmental Health Services and Mr. Julian R. Fleming, Director, Division of Sanitary Engineering, it was agreed that the study would generally follow the procedures used by the Bureau of Water Hygiene in its National Community Water Supply Study. The principal objective was to evaluate the total Tennessee Water Supply Program, and, if necessary, recommend improvements to assure safe, wholesome, drinking water for the residents of Tennessee.

It was agreed that investigation of a representative number of water supplies was sufficient to judge the effectiveness of the Tennessee Water Supply Program. A sample of public, "semi-public" and individual water supplies was selected for study. The technique used for selection was not intended to provide a perfect random sample. However, the results are considered to reasonably represent water supply practice in the State.

Five public water supplies were selected from each of the eight State Comprehensive Health Planning Regions on the basis of size, type of source, and treatment. These 40 supplies (later reduced to 39*) provide a cross-section of the State's public water supply practice and represent about one-tenth of all public supplies in the State. It is estimated that these 39 systems serve over 1,725,000 people or about 58 per cent of all those served by public water supplies. Five of the systems provide drinking water for commercial passenger carriers operating interstate. The number of interstate travelers so served is unknown. A list of the systems surveyed is tabulated in Appendix A and their location is shown in Figure 1.

Seventeen (17) of the 39 public water supplies selected for study adjust the fluoride content of their water for dental health protection. A special fluoride study was made of these and seven other systems, which were selected to provide a representative sample of the fluoride practice in the State.

For the purpose of evaluating "semi-public" water systems, three counties were selected for study, one in each of the geophysical

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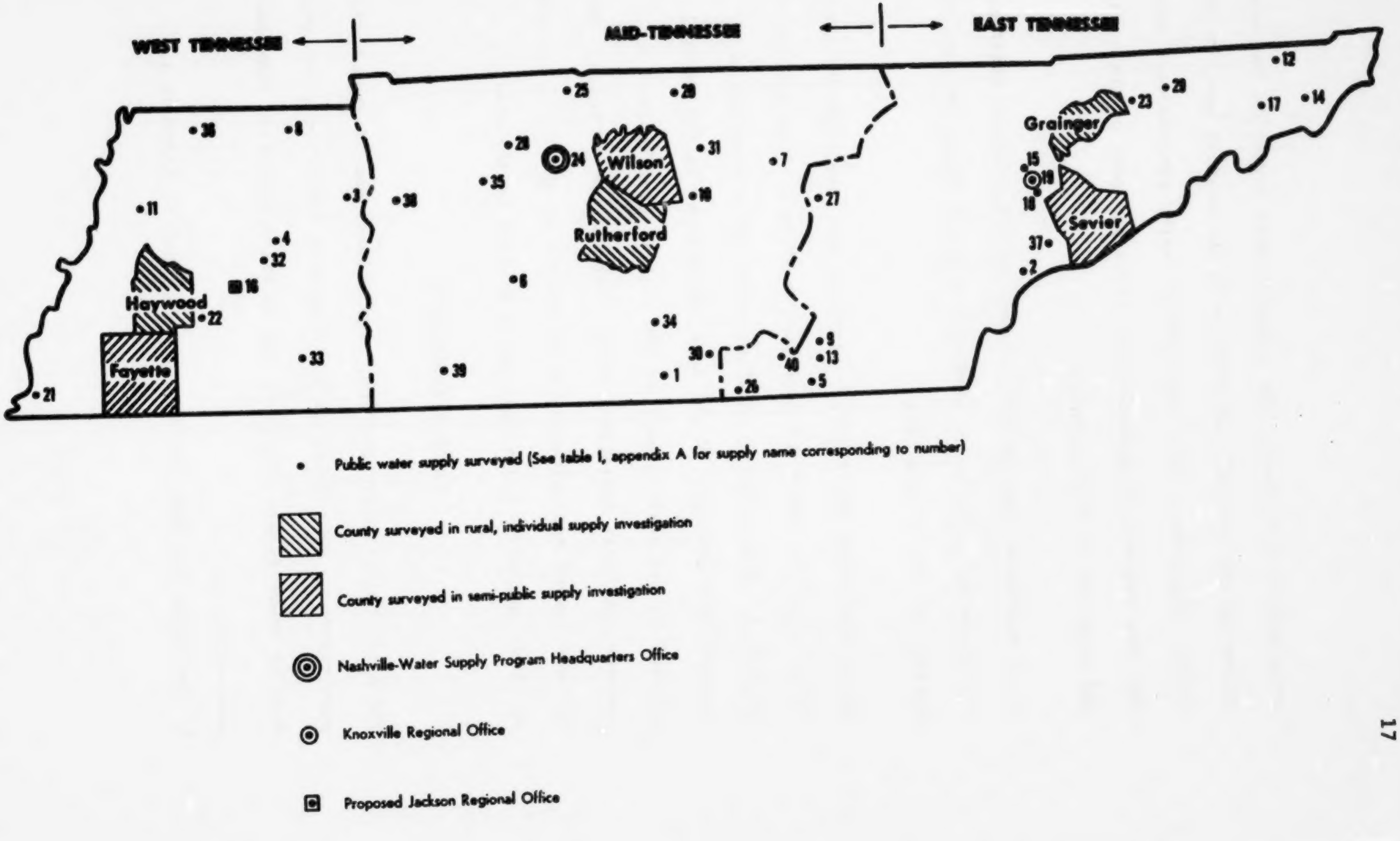
* One system deleted because extensive modifications were under construction.

FIGURE 1

LOCATION OF WATER SUPPLIES SURVEYED


WEST TENNESSEE
MID-TENNESSEE
EAST TENNESSEE
Haywood
Fayette
Wilson
Rutherford
Grainger
Sevier
• Public water supply surveyed (See table I, appendix A for supply name corresponding to number)
County surveyed in rural, individual supply investigation
County surveyed in semi-public supply investigation
Nashville-Water Supply Program Headquarters Office
Knoxville Regional Office
Proposed Jackson Regional Office

provinces of the State. The counties were Sevier in the east, Wilson in the central, and Fayette in the western part of the State. Sixty-four (64) "semi-public" water systems were surveyed, and this represents approximately eight per cent of the estimated 800 supplies in this category.

It is estimated that perhaps as many as 3.8 million* residents and travelers may drink water from this type of supply at some time during the course of a year.

Rural-individual water supply practice was investigated in three other counties, again one each in the State's three geophysical provinces. The counties in which rural water supplies were studied were Grainger in the east, Rutherford in the central, and Haywood in the western part of the State. Five hundred and seventy-one (571) individual water systems were surveyed. These systems served approximately 2,850 people or about 0.3 per cent of those served by individual water systems in the State.

PROGRAM EVALUATION

The basic water supply Statute, regulations, and program policies were reviewed. The Water Supply Program's activities, responsiveness to water supply problems, and staffing were also examined. A two-day and a three-day waterworks operators training course were monitored. Reported water-borne disease outbreaks were studied. Additionally, many residents, waterworks personnel, municipal officials, health officials and others were interviewed.

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* The bases for this estimate may be found in Appendix B.

Four bacteriological laboratories were surveyed and evaluated. These included the Department's Central Laboratory, a large water treatment plant previously certified by the Health Department, and two water treatment plant laboratories not previously certified. The Department Water Chemistry Laboratory and its chemical surveillance program were also studied.

EVALUATION CRITERIA

The effectiveness of the Tennessee Water Supply Program was gauged to a large degree on the bases of drinking water quality, adequacy and condition of water system facilities, and water supply surveillance.

Water Quality

Bacteriological quality of public water systems was judged by comparing the previous 12 months bacteriological record filed with or observed by the Health Department, with Public Health Service Drinking Water Standards. Any system failing to meet the bacteriological limits one or more of the past 12 months was considered to have failed the bacteriological standard. Since the Water Supply Program does not routinely sample "semi-public" and rural, individual water systems, they were judged on the basis of bacteriological samples collected during the field visit and examined by Health Department Laboratories. Any system having total coliforms in concentrations of 4/100 ml or more and/or having fecal coliform bacteria was considered to have failed the bacteriological standard.

Chemical quality of public water supplies was judged on the basis of water samples collected from the water treatment plant and from two or more locations near the extremities of the distribution system. Carbon filter and pesticide samples were also collected at treatment plants utilizing a surface water supply source. The samples were analyzed by Bureau of Water Hygiene and Bureau of Radiological Health Laboratories.

Each sample was compared singularly to the Public Health Service Drinking Water Standards and determined as either:

1. Meeting the Standards for all constituents, or
2. Not meeting one or more "recommended" constituent limit (some are aesthetic parameters), but meeting all "mandatory" constituent limits, or
3. Not meeting one or more "mandatory" constituent limit.

The chemical quality of rural, individual water systems was judged on the basis of chemical samples collected at the time of the field visit and analyzed by the Bureau of Water Hygiene Laboratory similar to the procedure used for public water systems. Unfortunately, laboratory resources were not available to run chemical analyses on the "semi-public" water systems. These were judged primarily on the basis of aesthetic acceptability (color, taste, odor, etc.)

Facilities

Public water supply source, treatment, operation and quality control were judged on the bases of the Manual for Evaluating Public Drinking Water Supplies and the Drinking Water Standards using the same interpretation as in the Community Water Supply Study for uniformity.

Source

Quality of the source was judged where possible by chemical analyses, and also by past experience of the treatment plant operator. Quantity was judged by historical experience and current water demands. Source protection was judged by the type of source, and potential and/or actual problems.

Treatment

Treatment was judged on the bases of the facilities and their operation (as observed on the day of the field visit), bacteriological records and chemical analyses. Disinfection was judged on the presence of a detectable free chlorine residual in all parts of the distribution system.

Distribution System

Finished water storage was judged adequate if elevated or non-pumped storage equaled or exceeded the system's average daily demand. Pumped storage was considered only where on-site internal conbustion or steam auxiliary powered pumping equipment were available. A distribution system pressure of at least 20 psi in all parts of the system was considered adequate for the purpose of this study. However, a minimum of 25 psi is considered desirable to insure optimum operation of all plumbing fixtures.

Quality Control

Record keeping practices were judged by records maintained at the water treatment plant or water treatment plant operator's office and available for inspection at the time of the field visit. The cross-connection control program was judged from the ordinance, program implementation and progress toward eliminating hazards.

As shown in Table III, Appendix A, water system facilities were divided into ten categories for examination and rating. Each system was then assigned a Risk Factor ranging from 0 to 10 which reflects the number of facility deficiencies found. Zero facility deficiencies ("0" Risk Factor) indicates least or little risk. Ten facility deficiencies ("10" Risk Factor) indicates most or high risk.

"Semi-public" and rural, individual water systems were judged on the basis of the Manual of Individual Water Supply Systems in addition to the references already cited. The adequacy of these facilities was judged on the basis of a sanitary survey accomplished at the time of the field visit.

Surveillance

Water supply surveillance was judged on the bases of the Drinking Water Standards and the Manual for Evaluating Public Drinking Water Supplies. Bacteriological surveillance was considered satisfactory if the average number of bacteriological samples examined per month during the preceding 12 month period met the minimum number specified by the Drinking Water Standards and monthly samples were routinely examined. Chemical surveillance was considered satisfactory if chemical constituents (as distinguished from normal in plant operational checks) were examined within the past three years and there was no record of significant problems. For the purpose of this survey, a rating by Division of Sanitary Engineering personnel sometime during the preceding 12 months was considered satisfactory. More frequent inspection, however, is considered necessary for optimum surveillance.

Other Criteria

Bacteriological laboratories were judged on the basis of the Public Health Service Manual entitled, Evaluation of Water Laboratories and Standard Methods. Chemical laboratory procedure was also judged by Standard Methods.

The adequacy of operator training was judged by the absence or presence of operational and quality control deficiencies.

FINDINGS

WATER SUPPLY STATUS

Water Quality

The bacteriological quality of Tennessee water supplies is reflected by the following:

> Thirty-one (31) per cent of the public water systems examined did not meet bacteriological standards one or more of the past 12 months; some failed as many as three months. These systems serve approximately 28,730 people.
>
> Fifty-nine (59) per cent of the rural, individual supplies examined failed to meet the bacteriological standards and fecal contamination was confirmed in approximately three-fourths of these cases. These systems serve approximately 1,680 people.
>
> Nineteen (19) per cent of the "semi-public" systems examined failed to meet the bacteriological standard and fecal contamination was confirmed in three-fourths of these cases. It is estimated that as many as 41,070 people (State residents and the traveling public) may be exposed to this water during one year's time.

Failure to meet bacteriological standards indicates a serious, potential health hazard and calls for prompt corrective action. Additional details and supporting data may be found in Appendices A, B, and C.

Chemical analyses of the water systems studied indicated that:

> Five (5) per cent of the public water systems examined failed to meet one or more of the mandatory chemical standards. These systems serve 179,800 people.
>
> Two (2) per cent of the rural, individual water supplies examined failed to meet one or more mandatory chemical standards. These systems serve approximately 57 people.

Drinking water must not contain any impurities which may be toxic or otherwise hazardous to human health. Drinking water failing to meet the mandatory chemical standards poses such a threat.

> Thirty-three (33) per cent of the public water systems examined failed to meet one or more of the recommended chemical standards. These systems serve over 926,500 people.
>
> Twenty-six (26) per cent of the rural, individual water supplies examined failed to meet one or more recommended chemical standards. Approximately 740 people are served by these systems.
>
> Thirteen (13) per cent of the "semi-public" water supplies examined were judged to have aesthetically undesirable chemical water quality. As many as

189,736 people may be exposed to this water during one year's time. Unfortunately, further chemical analyses of the "semi-public" water supplies was not possible at this time.

The recommended chemical standards are intended to assure that no constituent is present in quantities which impart objectionable taste, odor and/or undesirable physiological effects to drinking water, rendering it less than desirable or aesthetically inferior. Good quality drinking water should contain no impurity which would cause offense to the sense of sight, taste or smell, and should have chemical characteristics considerably better than the limiting values established by the recommended standards. A large percentage of the Tennessee supplies studied failed to meet these standards. See Appendices A, B, and C for additional details on chemical quality.

Facilities

Public Water Supplies

A sanitary survey of the water supply facilities of the 39 public water supplies studied revealed that:

(Sources)

Thirty-three (33) per cent had inadequate source protection.

Ten (10) per cent of the sources were of insufficient quantity.

Five (5) per cent of the sources had unsatisfactory raw water quality.

(Treatment)

Sixty-seven (67) per cent of the systems needed additional treatment facilities.

Sixty-two (62) per cent of the systems needed important changes in operation of present treatment facilities.

Thirty (30) per cent of those chlorinating failed to maintain chlorine residual in all parts of the system.

(Distribution)

Twenty-eight (28) per cent of the systems had inadequate distribution storage.

Twenty-one (21) per cent had inadequate water pressures in some or all areas of the distribution system.

(Quality Control)

Thirty-one (31) per cent of the systems were not maintaining adequate operational records.

Seventy-two (72) per cent of the systems were found to have inadequate cross-connection control programs.

Only two of the public water supply systems were found to meet the facilities evaluation criteria. The facilities of 95 per cent of the public water supplies were found to be deficient in one or more categories. One system had nine deficiencies; many had four or five. The average Risk Factor was 3.5 indicating a great potential hazard to public health. See Appendix A for additional details concerning public water systems.

Semi-Public Water Supplies

A sanitary survey of the 64 "semi-public" water supply facilities revealed that:

> Sixty-six (66) per cent of the systems needed additional treatment.
>
> Forty-six (46) per cent of the 26 systems chlorinating were found to have no chlorine residual.
>
> Nine (9) per cent were observed to have a visible sanitary defect.
>
> Eighty-four (84) per cent were rated less than "satisfactory".

"Semi-public" water systems serve a large number of people in Tennessee and the deficiencies enumerated above indicate a grave potential public health hazard. See Appendix B for additional details concerning "semi-public" systems.

Rural, Individual Water Supplies

A sanitary survey of the 571 rural, individual water systems indicated that:

> Nearly every system had one or more facility deficiency.
>
> Very few systems were constructed to prevent entrance of contamination.

These findings are supported by the fact that 43 per cent of the rural, individual systems were found to have fecal contamination. This poses a serious public health problem for the rural residents of Tennessee. Additional details may be found in Appendix C.

Fluoride Practice

One hundred and nineteen (119) public water supplies in Tennessee adjust the fluoride content of their water. These supplies serve 209 of the 445 public water systems. Approximately 46 per cent of the population of Tennessee receive fluoridated drinking water.

A study of 24 of the public water systems fluoridating revealed that:

> Not one system had a fully acceptable fluoridation program.
>
> Only 50 per cent of the systems were fluoridating at the proper level.

Seventy-nine (79) per cent were deficient in analytical control of fluoridation.

Seventy-five (75) per cent were deficient in fluoridation equipment and facilities.

Sixty-three (63) per cent were deficient in storage and handling of fluoride chemicals.

Seventeen (17) per cent of the operators were unfamiliar with analytical testing equipment and procedures.

Twenty-five (25) per cent of the operators did not accept or were otherwise not interested in fluoridation.

Operator Competence

Review of operator qualifications for the public water supplies studied indicated that:

Thirty-six (36) per cent were only part-time operators. One system did not have a designated operator.

Thirty-three (33) per cent of the operators were not certified by the Tennessee Department of Public Health.

Eleven (11) per cent of the operators had college level training. Seventy-six (76) per cent had received their waterworks training at State sponsored short schools. Thirteen (13) per cent of the operators had no formal waterworks training.

Eighty (80) per cent of the systems with an operator having no formal waterworks training failed to meet Water Quality Standards and/or had a Risk Factor of 3 or greater.

Seventy-nine (79) per cent of the systems with a part-time operator failed to meet Water Quality Standards and/or had a Risk Factor of 3 or greater.

Sixty-nine (69) per cent of the systems with a non-certified operator failed to meet Water Quality Standards and/or had a Risk Factor of 3 or greater.

Seventy-six (76) per cent of the systems with a short school trained operator failed to meet Water Quality Standards and/or had a Risk Factor of 3 or greater.

Fifty (50) per cent of the systems with a college trained operator failed to meet Water Quality Standards and/or had a Risk Factor of 3 or greater.

The operation of "semi-public" water systems varies widely with type and size of the establishment served. Often the owner, manager or person-in-charge also acts as water treatment operator. In some cases operation of the water facilities was delegated to maintenance personnel. Few, if any, of the "semi-public" water supply operators have received formal waterworks training.

Operation of rural, individual water supplies rests primarily with the homeowner or person(s) residing on the premises.

Surveillance

Of the 39 public water supply systems studied:

> Fifty-four (54) per cent failed to meet bacteriological surveillance standards.
>
> Eighty (80) per cent had not had a chemical evaluation during the past three years. The chemical quality of two systems was last checked 31 years ago. Several systems had no record of ever being checked for chemical quality.
>
> Forty-one (41) per cent of the systems had not been rated by a representative of the Tennessee Department of Public Health during the previous 12-month period.

Review of the 64 "semi-public" water systems indicated that:

> Seventeen (17) per cent had not had a health agency visit in the previous two years. In most cases, a visit consisted of collecting a water sample and did not include a full inspection of facilities and operational practices.
>
> In general, routine surveillance of "semi-public" systems was provided by county sanitarians who are not fully trained in maintenance and operation of water treatment facilities.
>
> Bacteriological and chemical surveillance were considered inadequate for systems serving the public.

There is no routine surveillance of rural, individual water supplies in Tennessee. Only those problems or complaints brought to the attention of State and local health officials are investigated. This places a heavy burden on the layman who obtains his drinking water from a rural, individual supply for it is he who must decide that a water supply problem exists and then seek assistance.

WATER SUPPLY PROGRAM

Authority

The Tennessee Department of Public Health (hereafter designated Department) administers the State Water Supply Program under Sections 53-2001 - 53-2008 of the Tennessee Code Annotated (Acts 1945, Ch. 52, Section 1; C. Supp. 1950 Section 5826.1). This Statute covers both public water supplies and sewerage systems.

Water Supply Regulations are promulgated by the Department's Division of Sanitary Engineering to provide for the supervision of public water supplies. The current Regulations were adopted by the Public Health Council on May 17, 1945 on behalf of the Department of Public Health.

In addition to the Statute and the Regulations, the Division of Sanitary Engineering establishes policies and procedures for the administration of the Public Water Supply Program.

Statute

The Public Water Supply and Sewer System Code (Appendix E) provides the Department with broad powers to supervise construction, operation and maintenance of public water supplies. Section 53-2001 defines a waterworks system as "the source of supply and all structures used for the collection, treatment, storage and distribution of water delivered to the consumers." It specifically excludes waterworks systems for private residences or waterworks for industrial purposes not intended for human consumption. A public water supply is defined as "any waterworks system as defined above, whether privately or publicly owned, where water is furnished to any community, collection or number of individuals for a fee or charge or any other waterworks system which on account of the people who are or may be affected by the quality of the water is classified as a public water supply by the Tennessee Department of Public Health." (Emphasis added).

Section 53-2002 gives the Department authority to exercise general supervision over construction of public water supplies. Such general supervision includes all of the features of construction of waterworks systems which do or may affect the sanitary quality of the water supply. No new construction shall be done nor shall any change be made to a water supply until plans have been submitted to and approved by the Department. The Department is empowered to adopt and enforce rules and regulations governing the construction of public water supplies and may require submission of water samples for examination.

Section 53-2003 authorizes the Department to investigate public water supplies as often as necessary to exercise general supervision over the operation and maintenance of these supplies. It may also adopt and enforce regulations governing such operation and maintenance. Provision is made for the submission of any necessary operating records and/or samples to the Department.

Section 53-2004 provides the Department with the power to regulate cross-connections, auxiliary intakes, by-pass connections or interconnections. Section 53-2005 states that if a public water supply is found to be an actual or potential menace to health and effective corrective measures are not carried out, the Department may issue an order for correction and specify a time limit for compliance. Section 53-2006 provides for a review of the necessity or reasonableness of any order issued by the Department.

Section 53-2007 provides that any person violating any provisions of the Statute or failing to comply with any lawful order of the Department, shall be guilty of a misdemeanor. Fines range from $10.00 to $100.00 for each violation or each day of continued violation. Section 53-2008 authorizes the Department to enforce any standards, policies, general or specific orders, rules or regulations to control public water supplies. It specifies that the district attorney in whose jurisdiction a violation occurs or the State Attorney General shall institute and prosecute suits when the necessity has been shown by the Department.

Regulations

The Regulations for public water supplies currently in use by the Department were originally issued on August 18, 1945 (See Appendix E) and have not been updated. A special provision covering fluoridation was added in April, 1963. The Regulations designate the Division of Sanitary Engineering as responsible for supervision of public water supplies and provides that the

Director of the Division will act as the authorized agent of the Commissioner.

Regulation W-1 states that the definitions of terms as set forth in Section 1, Chapter 52, Public Acts of 1945, shall be used in the interpretation of the Regulations. Regulation W-2 provides for supervision of construction by requiring preliminary plans, water samples, complete plans, plan revisions and conformity with approved plans. Regulation W-3 covers operational supervision by requiring submission of records, reports, and water samples. Regulation W-4 covers cross-connections, interconnections, etc. It specifically deals with non-potable water systems on the same premise where a public supply is available and prohibits cross-connections. It requires the labeling of the non-potable system and the filing of a cross-connection statement by the owner or operator of such a non-potable water supply. Regulation W-5 covers investigations, reports, standards and special orders.

The regulations do not specify minimum acceptable Drinking Water Quality Standards.

Policy

The Division of Sanitary Engineering's Water Supply Policy is contained in a number of individual publications and documents. The publications include: "Waterworks Operation Questions and Answers"; "Filter Plant Operation"; "Bacteriological Examination of Water"; and "Regulation of Reports, Plans and Specifications for Water Treatment Plants and Distribution Systems". Other documents include: laboratory equipment lists; special letters to all mayors, water superintendents and managers of utility districts; special reports to new water supplies; and staff meeting proceedings.

Resources

Organization

As discussed in the preceding section, the Tennessee Department of Public Health is charged with protecting public health through the administration of a Water Supply Program. The Department is made up of two major Bureaus, the Bureau of Personal Health Services and the Bureau of Environmental Health Services. An organizational chart is shown in Figure 2. The Division of Sanitary Engineering, Bureau of Environmental Health Services, is reponsible for the Water Supply Program.

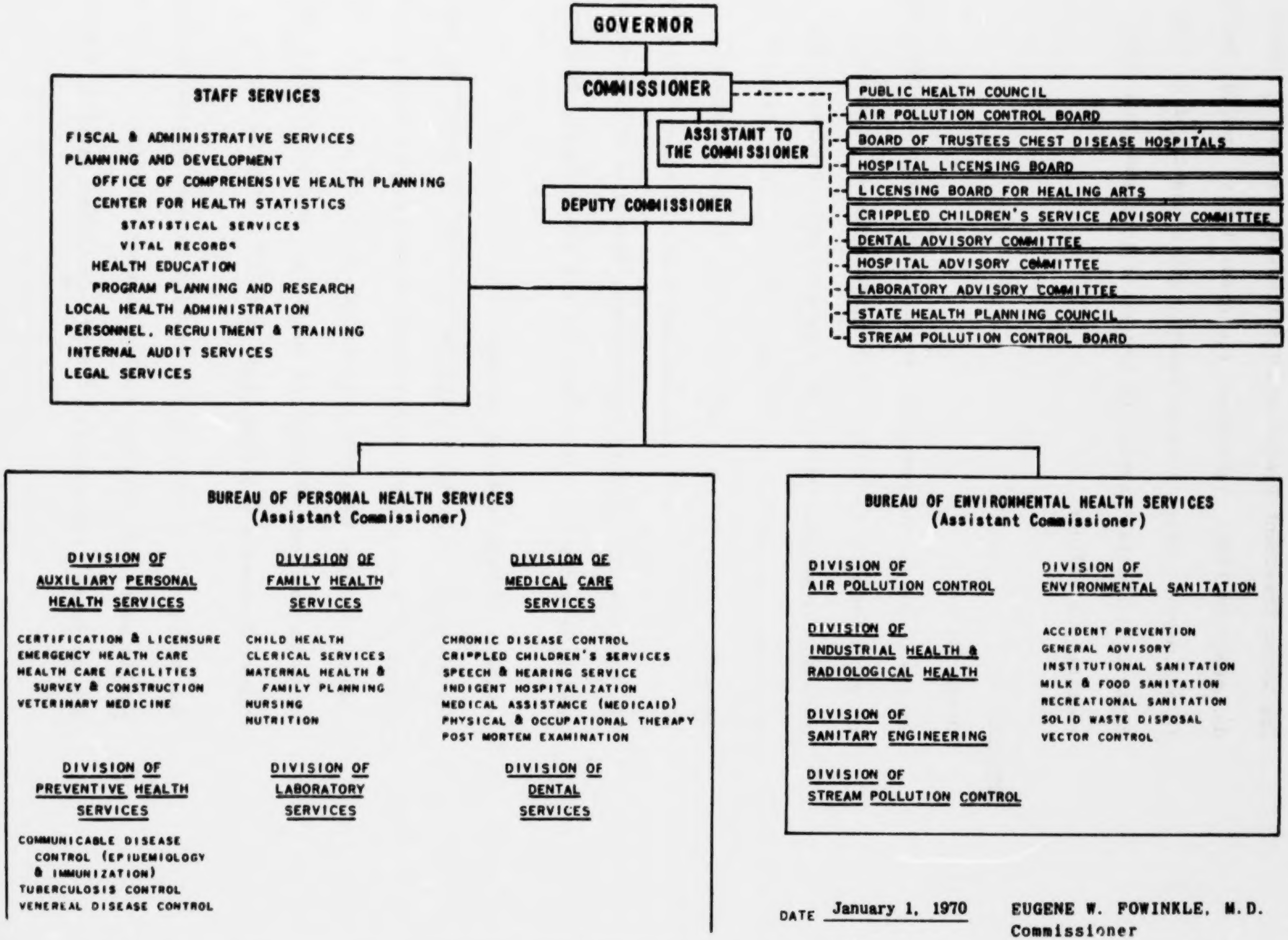
Division of Sanitary Engineering

The Division of Sanitary Engineering staff is presently comprised of a Director, an Assistant Director, and five sanitary engineers. One sanitary engineering position is vacant. The Division has four secretarial positions, one of which is vacant. Figure 3 shows a staffing chart for the Division.

The Division's activities are divided between supervision of public water supplies and public sewerage systems. Since there are no formal assignments of staff to either water or sewerage

Figure 2.

TENNESSEE DEPARTMENT OF PUBLIC HEALTH


GOVERNOR
COMMISSIONER
ASSISTANT TO THE COMMISSIONER
DEPUTY COMMISSIONER
PUBLIC HEALTH COUNCIL
AIR POLLUTION CONTROL BOARD
BOARD OF TRUSTEES CHEST DISEASE HOSPITALS
HOSPITAL LICENSING BOARD
LICENSING BOARD FOR HEALING ARTS
CRIPPLED CHILDREN'S SERVICE ADVISORY COMMITTEE
DENTAL ADVISORY COMMITTEE
HOSPITAL ADVISORY COMMITTEE
LABORATORY ADVISORY COMMITTEE
STATE HEALTH PLANNING COUNCIL
STREAM POLLUTION CONTROL BOARD
STAFF SERVICES
FISCAL & ADMINISTRATIVE SERVICES
PLANNING AND DEVELOPMENT
OFFICE OF COMPREHENSIVE HEALTH PLANNING
CENTER FOR HEALTH STATISTICS
STATISTICAL SERVICES
VITAL RECORDS
HEALTH EDUCATION
PROGRAM PLANNING AND RESEARCH
LOCAL HEALTH ADMINISTRATION
PERSONNEL, RECRUITMENT & TRAINING
INTERNAL AUDIT SERVICES
LEGAL SERVICES
BUREAU OF PERSONAL HEALTH SERVICES (Assistant Commissioner)
DIVISION OF AUXILIARY PERSONAL HEALTH SERVICES
CERTIFICATION & LICENSURE
EMERGENCY HEALTH CARE
HEALTH CARE FACILITIES SURVEY & CONSTRUCTION
VETERINARY MEDICINE
DIVISION OF FAMILY HEALTH SERVICES
CHILD HEALTH
CLERICAL SERVICES
MATERNAL HEALTH & FAMILY PLANNING
NURSING
NUTRITION
DIVISION OF MEDICAL CARE SERVICES
CHRONIC DISEASE CONTROL
CRIPPLED CHILDREN'S SERVICES
SPEECH & HEARING SERVICE
INDIGENT HOSPITALIZATION
MEDICAL ASSISTANCE (MEDICAID)
PHYSICAL & OCCUPATIONAL THERAPY
POST MORTEM EXAMINATION
DIVISION OF PREVENTIVE HEALTH SERVICES
COMMUNICABLE DISEASE CONTROL (EPIDEMIOLOGY & IMMUNIZATION)
TUBERCULOSIS CONTROL
VENEREAL DISEASE CONTROL
DIVISION OF LABORATORY SERVICES
DIVISION OF DENTAL SERVICES
BUREAU OF ENVIRONMENTAL HEALTH SERVICES (Assistant Commissioner)
DIVISION OF AIR POLLUTION CONTROL
DIVISION OF INDUSTRIAL HEALTH & RADIOLOGICAL HEALTH
DIVISION OF SANITARY ENGINEERING
DIVISION OF STREAM POLLUTION CONTROL
DIVISION OF ENVIRONMENTAL SANITATION
ACCIDENT PREVENTION
GENERAL ADVISORY
INSTITUTIONAL SANITATION
MILK & FOOD SANITATION
RECREATIONAL SANITATION
SOLID WASTE DISPOSAL
VECTOR CONTROL

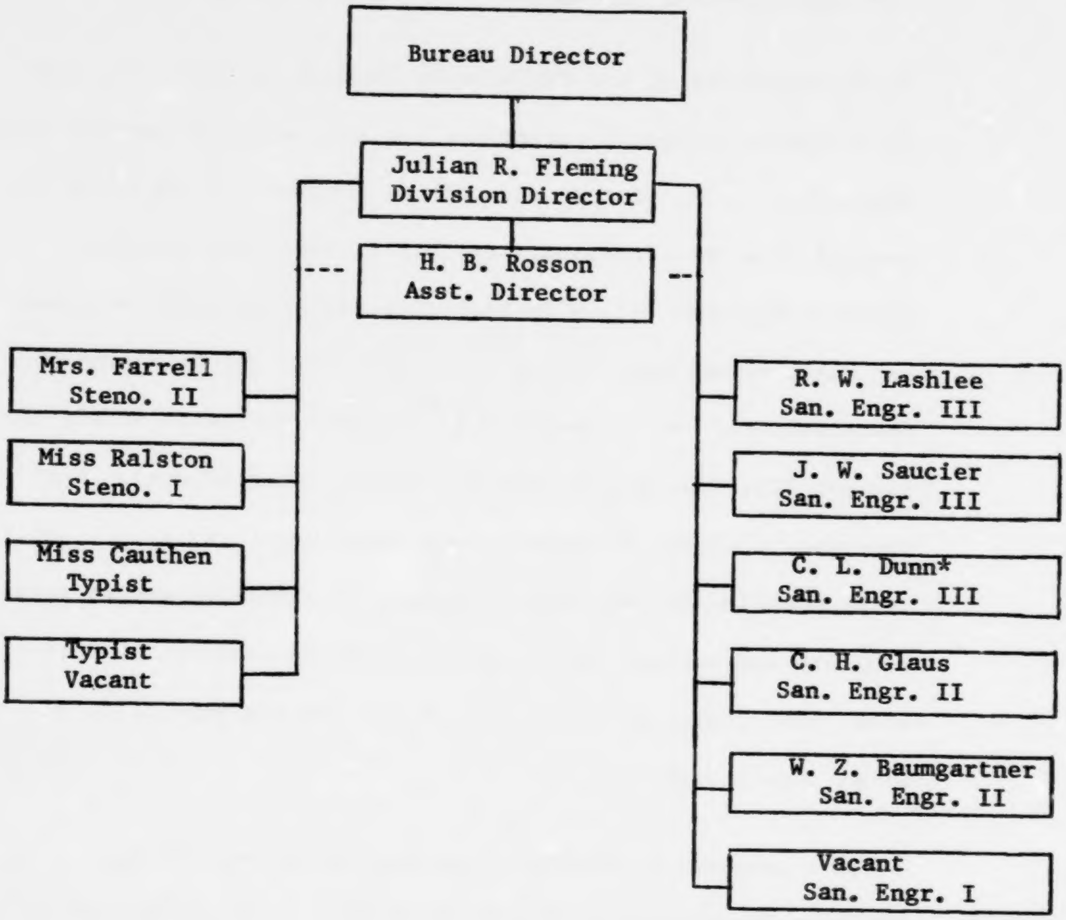
DATE January 1, 1970

EUGENE W. FOWINKLE, M.D.
Commissioner

FIGURE 3

DIVISION OF SANITARY ENGINEERING STAFF

1970


Bureau Director
Julian R. Fleming
Division Director
H. B. Rosson
Asst. Director
Mrs. Farrell
Steno. II
Miss Ralston
Steno. I
Miss Cauthen
Typist
Typist
Vacant
R. W. Lashlee
San. Engr. III
J. W. Saucier
San. Engr. III
C. L. Dunn*
San. Engr. III
C. H. Glaus
San. Engr. II
W. Z. Baumgartner
San. Engr. II
Vacant
San. Engr. I

*Located in Knoxville
Regional Office

activities, it is estimated that about one-half of the Division's staff time is devoted to water supply activities. Based on this estimate, the Water Supply Program is currently being administered with approximately 3½ engineers and 1½ secretaries.

The headquarters of the Division is located in Nashville, and all Division personnel except one sanitary engineer operate from this office. The western and central portions of the State are covered from this location. On July 1, 1967, the Division opened a Regional Office in Knoxville and permanently assigned one sanitary engineer to the location. This office's area of responsibility was established as all East Tennessee within the Eastern Time Zone except Hamilton County (Chattanooga). East Tennessee includes 29 counties and about one-third of all public water supplies in the State. Because of limestone ground water aquifers and surface water quality problems inherent to this area, this region presents some of the State's most difficult water supply problems.

Table I presents a summary of the qualifications of the Sanitary Engineering professional staff. It is considered noteworthy that all hold Masters' Degrees and that all hold Professional Engineers Licenses except the Sanitary Engineer II's, who have not obtained sufficient experience to qualify for the examination.

TABLE I

SANITARY ENGINEERING PROFESSIONAL STAFF QUALIFICATIONS

ENGINEER	CATEGORY	ANNUAL SALARY	BACHELORS DEGREE	MASTERS DEGREE	PROF. REGIS.	PREVIOUS EXPERIENCE
Fleming, Julian R.	Env. E. V	$18,240	U. Tenn. 1934	U. Tenn. 1935 U. Iowa 1941	Tenn.	Tennessee Eastman Cor Greeley and Hansen Engineers Assoc. Prof. San. E. U. of Tenn.
Rosson, Harrell B.	San. E. IV	17,040	Okla. St. 1952	Okla. St. 1953	Tenn. Okla.	Infilco Corp. Markwell & Hartz Wallace & Tiernan Inc
Lashlee, Robert W.	San. E. III	15,360	U. Tenn. 1957	Purdue 1961	Tenn.	None
Saucier, John W.	San. E. III	14,820	Miss. St. 1962	U. Mich. 1965	Tenn.	None
Dunn, C. Lamar	San. E. III	13,740	Tenn. Tech 1964	Vanderbilt 1967	Tenn.	None
Glaus, C. Henry	San. E. II	11,760	Tenn. Tech 1967	Okla. St. 1970	Tenn. EIT	None
Baumgartner, Wm. Z., Jr.	San. E. II	11,760	Vanderbilt 1966	Vanderbilt 1969	Tenn. EIT	None

The professional staff is well qualified and has displayed an exemplary dedication to duty. During the six month period from October 1969 through March 1970, two staff members who keep day-to-day records of their activities worked an average of 302 hours of non-compensated overtime. It is conservatively estimated that the six-man staff (one member was on study leave at the time) contributed approximately 1-1/2 man years of extra, non-compensated overtime last year. This amounts to a 125 per cent effort and no agency can expect its employees to perform under these conditions indefinitely.

Current professional salaries are also shown on Table I. It is noted[1] that Tennessee ranks 15th among States in salary paid to the Director of Public Health Engineering and 18th in salary paid to beginning public health engineers.

The Division of Sanitary Engineering budget for Fiscal Year 1969-70, not counting a special program for on-the-job training of sewage treatment plant operators, was $138,995. This amounts to approximately 9.9 per cent of the total Bureau of Environmental Health Services budget. Even though the Division's budget has been increased by about $36,000 in the past ten years, this amount was necessary to maintain salary levels, and no actual growth occurred. Sanitary Engineering expenditures decreased from 24.5 per cent of the amount spent for all environmental health activities in 1960 to 21.8 per cent in 1965 and 9.9 per

---

/1 State Salary Ranges, DHEW, Office of State Merit Systems cent in 1970. During this same period, the number of public supplies requiring surveillance increased from 299 in 1960 to 445 in 1970, and the population served by these supplies increased by over one-half million people.

Using the same equal division of resources between water supply and sewerage activities as before, it is estimated that approximately $69,500 was expended on the Water Supply Program for FY 1969-70. This amounts to only about $107.50 for supervision of each of the 445 public water supplies in Tennessee and only about $27.00 each for the estimated 800 "semi-public" water systems (on the premise that the average effort expended on a "semi-public" supply should be about one-fourth that spent on a public system.)

Other Assistance

The Division of Laboratories, Bureau of Personal Health Services, provides bacteriological laboratory support for the Water Supply Program. Water bacteriological laboratories are located in Chattanooga, Jackson, Johnson City, Knoxville, Memphis, and Nashville. The Division of Laboratories also assists by evaluating and certifying the acceptability of procedures used by other water bacteriological laboratories in the State which are associated with interstate carrier water supplies.

The Division of Stream Pollution Control provides limited chemical analysis of drinking water at its laboratory in Nashville. City and county health departments may refer problems to the Division of Sanitary Engineering and render assistance at the local level.

Activities

Engineering

As stated previously, the engineering activities of the Tennessee Water Supply Program are conducted by the Division of Sanitary Engineering, Tennessee Department of Public Health. Regulations prescribe that the following engineering services will be provided:

1. Engineering inspection of facilities and operation of all public water supplies, including cross-connection control.
2. Review of plans and specifications for new construction and modification of existing systems.
3. Surveillance and final inspection of construction.
4. Training of water plant operators.
5. Promotion and supervision of fluoridation.
6. Review of monthly operating reports from all public water systems.

Advisory services to local health departments and other services are also provided:

1. Assistance to local health departments for engineering surveillance of semi-public and individual water systems.
2. Assistance to other State agencies by engineering surveillance of State-owned water supplies.

To meet these responsibilities, the Water Supply Program has adopted a policy that engineering inspection of all public water supplies will be made twice per year. However, staff limitations have never allowed this policy to be implemented. In 1969, 196 public water systems (approximately 47 per cent of the total in Tennessee at that time) were inspected and rated.[2] Of these inspected systems, 79 were rated "approved" and 117 were rated "not approved". The remaining 220 public water systems were not inspected in 1969 and included 48 systems which had never been rated by the Tennessee Water Supply Program.

Essential to the engineering inspection activity is the "rating" system. Following a field inspection, the water system is assigned a numerical score to reflect the condition of physical equipment, the type of operation and maintenance, and the quality of water delivered. A copy of the Rating Form is included in Appendix E. The ratings range between zero and 100, and only those systems scoring 90 or better receive an "approved" classification.

The field evaluation of 39 water systems revealed some significant findings regarding the engineering inspection and rating program. The Tennessee Water Supply Program had inspected 59 per cent of these 39 water systems during the past year. However, Bureau of Water Hygiene field evaluations indicated that only 33 per cent of the 39 water systems had

---

/2 Public Water Supply Systems in Tennessee - 1969, Tennessee Department of Public Health, 36 pp.

a risk rating of less than three (3). A comparison of the risk rating and the State's numerical rating is presented in Table V, Appendix A. Of the twenty (20) water systems that were rated "approved" by the State, twelve (12) were found to have a high relative risk rating of 3 or greater indicating that the ability of these water systems to continually deliver safe drinking water is suspect.

The review of 275 plans and specifications by the Water Supply Program required approximately 1¼ man-years of professional time in Fiscal Year 1970. The review activity is required by law and involves detailed calculations. A concentrated effort has been made to carry out this activity often at the sacrifice of other important activities. However, the related responsibility for supervision and inspection of the resultant construction projects is seldom carried out.

The Water Supply Program conducts regional operator training short schools and provides on-site training during water system engineering inspections. In September 1969, it was determined that this training program had certified operators for 218 water systems or 52.4 per cent of the total public water systems in Tennessee. During a six-months period (October 1969 to March 1970) the Water Supply Program reported that it had conducted eight water works operator schools. A total of 968 man-hours of engineering time were devoted to short school training of 386 operators. This evaluation's field survey of 39 water systems found that 67 per cent had certified operators and that 76 per cent of the operators had received State short school training.

The Water Supply Program is also seeking a Department of Labor grant for 1971 to provide on-the-job training for 150 water plant operators. Excellent experience with two earlier grants for wastewater operators encouraged this attempt, but because of funding limitations it is unlikely this project will be initiated.

Advisory service to local health departments and other State agencies has not been a priority activity. The Water Supply Program has prepared an initial inventory of "semi-public" water supplies and has provided some infrequent service to these supplies. In 1969, an administrative study was made of private water supplies ("semi-public" and rural) in Tennessee based on review of bacteriological samples analyzed by the Division of Laboratories during that year. Of 6,843 samples examined in 1969, 47.5 per cent were positive for coliform organisms. Of these 6,843 samples, 1,094 were from supplies treated by chlorination, and 20.8 per cent of these 1,094 samples were reported positive. This information was substantiated by the laboratory results of the "semi-public" water supply study (Appendix B) and the rural, individual water supply study (Appendix C). Twenty (20) per cent of the samples collected from "semi-public" water supplies were positive for coliform (19 per cent failed the bacteriological standard) and 59 per cent of the samples collected from rural, individual water supplies were positive for coliform organisms.

Laboratory

Laboratory surveillance of drinking water quality in Tennessee is divided among many individuals and agencies. Sample collection may be done by Division of Sanitary Engineering personnel, county sanitarians or water plant operators. Analyses may be performed by the Division of Laboratories, Division of Stream Pollution Control, private laboratories, or the water purveyor. Only 41 per cent of the public water supplies surveyed in this evaluation had collected a sufficient number of bacteriological samples over the previous twelve months. Only 20 per cent had a chemical analysis of the water within the past three years, and this analysis did not include all constituents listed in the Drinking Water Standards.

Bacteriological

The bacteriological laboratory services of the Department of Public Health are provided by the Division of Laboratories, Bureau of Personal Health Services. The Division of Laboratories operates a central laboratory in Nashville and branch laboratories in Chattanooga, Jackson, Johnson City, Knoxville, and Memphis. This geographical spread enables sample travel time to be maintained within the 30 hour limit prescribed in Standard Methods. The current sampling policy of the Water Supply Program is that all public water supplies must submit to the proper state laboratory two (2) samples each month from the distribution system for bacteriological examinations. It has also been recommended that all filtration or softening plant systems (capacity $\geq$ 0.2 mgd) and other systems (capacity $\geq$ 1.5 mgd) should maintain their own bacteriological laboratory. Consequently, there are eighty-five (85) water systems performing bacteriological analyses and fourteen (14) other water plants which have the necessary equipment but are not performing the analyses.

Samples collected by State, county or water works personnel and submitted to the State laboratories are considered "official" while samples analyzed at water plant laboratories are not considered "official" except where the laboratory has been certified by the State. The information reported in Table IV - Appendix A indicates that the number of "official" samples examined for 21 of 39 water supplies was insufficient to meet requirements of the PHS Drinking Water Standards.

As part of the study of the Tennessee Water Supply Program, the Central State Laboratory and three water plant laboratories were evaluated. (See Appendix F). One of the water plant laboratories had been previously certified by the State as an interstate carrier laboratory. The Central State Laboratory was found to be in substantial compliance with accepted procedures for bacteriological examinations as was the previously certified water treatment plant laboratory. The two water plant laboratories not previously visited or certified by the laboratory certification officer were found to be using unacceptable methods or procedures. One was found to be in such noncompliance that it was recommended that all previous data from the laboratory be marked "void" and stricken from the record.

The PHS Drinking Water Standards specify that remedial action for unsatisfactory bacteriological samples include daily resampling and immediate active steps to locate and eliminate the source of pollution. The Tennessee Water Supply Program requires such actions. Whenever unsatisfactory sample results are reported, two additional sample bottles are sent to the operator along with the unsatisfactory report that includes the following statement:

> "Samples showing evidence of contamination require repeated testing from the same location until two successive negative results are obtained. Two bottles are being forwarded for immediate daily sampling."

A review of the records, however, show that this policy is not being effectively implemented.

The data displayed in Table III, Appendix F, indicate three points:

a. The lack of resampling from the same location on successive days until two negative results are secured.
b. The slow processing of positive results by the Central Laboratory reporting section.
c. A lack of understanding by some sample collectors as to what constitutes the proper response to positive laboratory results.

The problem at the Central Laboratory is apparently related to lack of staff and resources for record keeping and reporting. This data handling delay has, in part, defeated efforts of the laboratory to give a rapid monitoring of water supplies. Results are available from the membrane filter procedure within 24 hours, but an average of five days was required before the water systems was notified.

Similar inspection of records at two of the branch laboratories indicate that these laboratories are providing sufficient response.

Chemical

The water chemistry laboratory of the Tennessee State Department of Public Health is operated by the Division of Stream Pollution Control at the Central Office in Nashville. In 1969, the laboratory analyzed 1,132 samples for Stream Pollution Control purposes and 178 for drinking water quality surveillance. About half of these 178 analyses were of private wells, springs, or cisterns and the remainder were of new public water supplies. None were routine surveillance of previously existing water supplies. According to a survey made by by the Division of Sanitary Engineering in 1966,[3] of 415 public water supplies in the State at that time, the chemical quality of 81 had not been checked in the last 15 years and 60 had never been checked.

During the field surveillance activities of this study, it was noted that only 20 per cent of the 39 water systems had had a chemical analysis performed on their water during the past three years. The majority of those performed were done by the water supply laboratories of the larger systems or by commercial laboratories.

As a part of this program evaluation, a special evaluation of the Stream Pollution Control Laboratory was conducted.

/3 "Selected Chemical Content of Waters Used by Public Supplies", Tennessee Department of Public Health.

Analyses performed, methods, equipment, staffing, and space requirements were examined. Routine chemical analysis of drinking water, as currently practiced by the laboratory, includes alkalinity, hardness, iron, chloride, fluoride, pH, calcium, color, and turbidity. Other constituents which are occasionally determined are manganese, sulfates, nitrates, surfactants, and zinc. This constitutes adequate surveillance for operational purposes, but only a partial chemical analysis of drinking water as compared with the extent of analyses called for in the PHS Drinking Water Standards. Trace metals, organics, and pesticides are not currently being run for public water supplies, although the laboratory is equipped to run most of these constituents. The laboratory does not normally run even such simple determinations as total dissolved solids or conductivity.

The methods and procedures of the Stream Pollution Control Laboratory were found to be in general conformance with those outlined in Standard Methods. Laboratory equipment was available to run most of the analyses that are essential to surveillance of drinking water. There was an atomic absorption spectrometer which could be used for the trace metals analysis. There was also equipment for organic contaminate determinations (carbon chloroform extractions) and pesticide determinations which are currently run only for pollution control work. However, it was found that the dionized water facilities in the laboratory were not being monitored for quality and that the turbidimeter used for water supply analysis did not have the sensitivity necessary for drinking water supply work.

Space allocations of this laboratory appear to be adequate. The quality of personnel is excellent. The staff includes two chemists with master degrees, four with bachelor degrees, and one technician.

Chemical laboratory capability was found at 23 of the 39 water systems surveyed. The water purveyor does not perform, and is not required by the State to perform anything more than a partial chemical analysis, primarily to monitor water treatment operations. These analyses include alkalinity, CO_2, turbidity, chlorine residual and pH. Of the 23 water systems with chemical laboratories, only four had more than this capability, and none had the ability to analyze the full range of constituents listed in the Drinking Water Standards. Several large water systems which treat water drawn from the Tennessee River downstream from industrialized areas are trying to develop the capability to analyze for trace metals and exotic materials.

Analysis for radiochemical constituents has never been routinely performed for drinking water supplies in

Tennessee. The Tennessee Department of Public Health has the competency and the equipment to perform this function in their Division of Industrial Health and Radiological Health.

DISCUSSION

PUBLIC HEALTH RISK

Water Supply Deficiencies

Public health protection of drinking water supplies should assure that each component of the production, storage and distribution process function without risk or failure. Flawless treatment avails nothing if the distribution system permits entrance of contamination through faulty facilities or cross-connections. Similarly, excellent operation of conventional water treatment and distribution facilities will not protect public health if impurities are present in the raw water source which are not amenable to treatment.

Documented incidents have shown that disease outbreaks resulted when contamination of water and inadequate chlorination practices occurred at the same time. As presented in the findings, not all public and "semi-public" systems provide chlorination. Thirty (30) per cent of the public and 46 per cent of the "semi-public" systems which have chlorination facilities do not maintain chlorine residual in all parts of the distribution system. In addition, 31 per cent of the public supplies, 19 per cent of the "semi-public" supplies, and 59 per cent of the rural, individual supplies were found to show evidence of bacteriological contamination. These conditions present serious public health risks.

More industrial and agricultural chemicals, toxic to humans are finding their way into our natural waters than ever before. Conventional water treatment processes do not always remove these chemicals. Assurance that these substances are not present in drinking water can only be given by (a) adequate protection of raw water sources, and (b) a surveillance program providing routine complete chemical analyses. It was found that 80 per cent of the supplies surveyed had not had a chemical analysis during the previous three years, and some had never been analyzed. Further, chemical surveillance presently performed does not include analysis for many constituents included in the Drinking Water Standards and others of known health significance. Thirty-three (33) per cent of the supplies surveyed failed to provide adequate protection for their raw water source, indicating contamination by potentially dangerous substances may be occurring undetected by water supply officials.

Tennessee drinking water supplies are vulnerable to enteric disease transmission and are not providing sufficient protection against other hazardous impurities.

Water-borne Diseases

Water-borne disease epidemics are documented to have occurred in Tennessee in recent years. In addition, epidemiological records indicate that potentially water-borne diseases occur each year. (See Appendix G). While Tennessee has approximately two per cent of the nation's population, about three per cent of the infectious hepatitis, three per cent of the shigellosis, and five per cent of the typhoid occurred in Tennessee. A portion of these cases, plus an unknown number of unreported cases, may have been water-borne.

In addition, body wastes from these diseased persons pose the constant threat of contaminating drinking water supplies.

In essentially all documented water-borne epidemics, definite water system deficiencies were shown to exist during the time when disease was transmitted. Similar water systems deficiencies were noted during this evaluation, and are discussed in the preceding section. The requisites for repetition of the tragic epidemics of the past, namely, vulnerable water supplies and persons infected with potentially water-borne diseases, are still present in Tennessee. Greater vigilance by health officials and the water supply industry is necessary in order to minimize public health risk from drinking water.

PROGRAM NEEDS

Authority

Statute

The Statute appears to be generally well written and provides the Tennessee Department of Public Health with broad regulatory and investigative powers to supervise construction, operation and maintenance of all public water supplies, and to issue enforceable orders for correction of water system defects which cause a health menace.

The Statute allows the Department to define which supplies are to be considered as "public". It appears as though "semi-public" (restaurants, motels, subdivisions, trailer courts, parks, recreation areas, etc.) and industrial plant potable water supplies are covered by the act and could be placed under surveillance by the Department at its option. However, the Statute definitions need to be strengthened and clarified on this point.

No specific provision is included in the Statute for the promotion and orderly development of new public water supplies. Language similar to that discussed in the Public Health Service Publication, Recommended State Legislation and Regulations which provides for comprehensive community plans would be helpful.

The definition of a cross-connection and Section 53-2004 should specifically prohibit any physical connection or arrangement between two otherwise separate piping systems, one of which contains either water of unknown or questionable safety, or stream, gas, or chemical, whereby there may be a flow from one system to the other, the direction of flow depending on the pressure differential between the two systems.

During the 25 years since the Department obtained the authority to issue enforceable orders, four orders have been issued. The events preceding the issuance of these orders were examined, as were other situations where orders were considered, to evaluate the Department's willingness to use all means under law available to protect the public health.

Only two orders were issued between 1945 and October 1970, reflecting a definite reluctance on the part of the Department to issue compliance orders. Files indicate, for example, that this reluctance prevailed in spite of a Department Field Epidemiologist's report which concluded ten persons had contracted infectious hepatitis through a contaminated water supply, and the Sanitary Engineering Division Director's recommendations that the implicated water system be closed down by Departmental Order.

One order was issued in October 1970, and another in November. In both cases the supplies in question had been visited repeatedly over a period of several years by Department engineers and had received correspondence which included strongly worded recommendations to correct certain major deficiencies.

From the examination of the files, it appears that while the Department has retained its strong preference for obtaining progress through persuasion, it is now willing to resort to legal techniques at its disposal when other means have failed. This is considered a necessary and proper exercise of the responsibility to protect the public health, and its continued use, as prescribed by present law, is encouraged.

While the fact that two orders were issued in 1970 is commended, comment is appropriate regarding the interval of time between full awareness of one situation meriting such action and actual execution of the order. On August 26, 1970, internal correspondence of the Department documented that a certain water supply presented a menace to health and had not made satisfactory progress toward corrections. It cannot be ascertained from the records whether an immediate decision was made to issue the order or whether some time was spent reaching this decision. It is significant, however, that an order to correct a situation judged to constitute a health menace was not issued until November 17, 1970. This delay, which approaches three months, indicates either cumbersome and unresponsive administrative procedures and/or lack of resolve to act in the interest of public health on the part of responsible officials.

The $10.00 to $100.00 penalty for violating the provisions of the Act or directives of the Department appears to be very minor in comparison to the potential public health problems created by an improper public water supply. For example, the Tennessee Stream Pollution Control Law, Section 70-317 provides for fines five (5) times as great as those specified in the Water Supply Act. In view of the fact that stream pollution has only an indirect health affect, whereas a water supply has a direct and immediate effect on public health, the penalty provisions of the Water Supply Act are considered inadequate. Under the present law only the District Attorney or the State Attorney General shall institute and prosecute suits. The Department's role would be strengthened considerably if it were authorized to bring suit in its own right.

It is noted that authority conferred by Statute has been extended to cover certain public drinking water by the Tennessee Department of Conservation. The Division of Water Resources, under the authority of Chapter 23 of Title 70, Tennessee Code Annotated 70-2301 et. seq., licenses water well drillers for the orderly development of the State's underground water resources. This agency has developed rules and regulations in order to protect groundwater resources from contamination, to supply water of reasonable quality, and to protect public health. Regulations governing water supplies at restaurants and hotels have been promulgated by the Division of Hotel and Restaurant Inspection, Tennessee Department of Conservation, under statutory authority granted in the Code of Tennessee 1932, and the Public Act of 1937. Regulations pertaining to restaurants require use of public water supplies if available. If an approved public supply is not available, annual bacteriological testing is required, and the laboratory report must be displayed. Provision is made for arbitration of conflicts which may occur between these regulations and City or County health agencies. No mention is made, however, of State water supply regulations. Regulations pertaining to hotels require only that "pure, wholesome" drinking water be provided to guests.

Section 53-3802, Tennessee Code Annotated, gives the Commissioner, Tennessee Department of Public Health, authority to adopt rules and regulations for the health protection of persons using organized camps in the State. Regulations issued under this authority specify general water hygiene practice and require bacteriological samples, one before camp opening each year and at least one during camp operation.

It can be seen that programs administered by the Department of Conservation and the Camp Sanitation Service of the Department of Public Health parallel and somewhat duplicate program for which the Division of Sanitary Engineering has principal responsibility. None of the regulations specifically refer to the others. Closer coordination and cooperation between these agencies is obviously necessary, and the regulations of other agencies should reflect that principal authority for regulation of public drinking water supplies has been given to the Division of Sanitary Engineering.

Regulations

Clearly, the Department's Water Supply Regulations need to be updated and strengthened. While the Division of Sanitary Engineering is still a functional agency of the Department, it has been largely superseded by the Bureau of Environmental Health Services as the primary environmental health agency of the Department. The Regulations should recognize this organizational change. Provision should also be made for more and better coordination with other agencies of the Bureau, such as Division of Stream Pollution, Division of Environmental Sanitation, and the Solid Waste Section, since the activities of these agencies have a direct bearing on water supplies in the State.

As noted in the preceding section, no provision is made for the promotion and orderly development of new public water supplies. The Regulations do not specify that waterworks design and/or the preparation of plans and specifications must be by a professional engineer properly registered in the State of Tennessee for this type of work. The provision requiring all waterworks plans, specifications, and changes in plans to be submitted for review and approval is important. The suitability of proposed waterworks construction must be determined in order that the public health may be properly protected. The Regulations require the submission of such plans at least two weeks prior to the date action is desired. This is considered far too short a time to adequately review all details of a complex design or proposal, particularly when the design may be vague and/or incomplete. Only the simplest waterworks improvement can be reviewed in two weeks.

In order to assure continued maintenance and safe operation of all water supplies serving the public, it is mandatory that an individual or legally constituted group be designated as responsible for the supply. Without such a designation, proceedings to enforce elimination of menaces to public health are ineffective.

The Regulations should specify the general types of waterworks which are considered public water supplies. Supplies such as those serving restaurants, motels, service stations and similar commercial establishments; trailer courts; Federal, State, local and privately owned parks; recreational areas; amusement parks; Federal, State, local and privately owned institutions; industrial plant potable water systems; food processing establishments; and all other similar water systems which on account of the people who are or may be affected by the quality of the water should be designated public water supplies. It is suggested that such systems be classified so that different types may be singled out or excluded from certain provisions of the Regulations, depending upon their particular significance.

Although not specifically granted in the Code, the Department's authority for general supervision over construction of public water supplies includes approval of the source of supply. In order to adequately assess the suitability of a proposed water source, water quality data should be compared to accepted water quality standards. The Tennessee Stream Pollution Control Board has adopted water quality criteria for surface waters suitable for use as domestic raw water supply. The Department's Water Supply Regulations, however, do not include raw water standards. Standards published in the Public Health Service's *Manual for Evaluating Public Drinking Water Supplies*, and the Federal Water Quality Administration's *Water Quality Criteria* are recommended. No provision is made for the prohibition of bathing, water skiing, boating or other activities in or near waters used as a source of public water supply if evidence indicates that such use may adversely affect the water supply. It is recommended that this feature be included in future Regulations.

The adequacy of the water supply source in relation to current and reasonable future demands should be ascertained and substantiated by geological, stream flow, weather or other records. Location and restriction of well water sources should be covered. Sealing of all abandoned or unsatisfactory wells should be required.

Finished water standards should be specified and bacteriological, chemical, physical and radiochemical limits set. The Public Health Service's latest *Drinking Water Standards* are recommended as "minimum" standards for all public water supplies.

The bacteriological and chemical laboratory facilities considered necessary for each type or class of water supply should be specified as well as the type, number, and frequency of the raw and finished water examinations. The bacteriological frequency specified for finished water in the PHS Drinking Water Standards is recommended as "minimum".

Operator certification should be covered in the Regulations and should specify the level of training and experience considered necessary to operate the various types and sizes of waterworks. Mandatory certification is recommended.

Minimum acceptable water system pressures should be specified. A minimum of 25 psi in all parts of the distribution system is recommended. Mandatory chlorination is recommended. The Regulations should require that a detectable free chlorine residual be maintained in all parts of a water supply distribution system serving the public and should specify the test procedure to be used for monitoring chlorine residual.

Disinfection of all newly constructed waterworks, extensions, modifications or major repair should be mandatory. Facilities should be withheld from service until bacteriological samples indicate that the disinfection was satisfactory.

The Ten States Standards[4] are also suggested as a guide for updating and revising the Tennessee Regulations.

/4 Recommended Standards for Water Works, Great Lakes - Upper Mississippi River Board of State Sanitary Engineers.

Policy

It is unfortunate that a single water supply policy document is not available for the Division of Sanitary Engineering's Water Supply Program.

Recently the Division instituted a procedure whereby Policy is established or changed in staff meetings. Although the minutes of these meetings are circulated, it would be much better if each staff member had his own policy manual and received insert sheets covering all policy changes. Even with the very small staff, problems have arisen because the staff was not familiar with the latest Division policy or had forgotten that it had been changed during a recent staff meeting. Exceptions to standard policy and special considerations have not been recorded as well as perhaps they should.

Activities

Engineering

The findings of this evaluation, reviews by the State Department of Public Health Comprehensive Health Planning Program, and reports prepared by the Water Supply Program, all emphasize that the Tennessee Water Supply Program is not providing the engineering services necessary to fulfill its delegated responsibilities. This conclusion was well stated in a circular of the Division of Sanitary Engineering in April 1970, entitled, "Is that all?". It is appropriate here to restate the last four paragraphs of this article with important phrases underlined.

> "At the present time, there exist 270 public wastewater systems and 441 public water systems in the State of Tennessee. Actually, each of these systems should be visited at least twice each year for a routine investigation, but due to the lack of sufficient personnel many of the systems have not been visited since 1966. Many of the visits that have been made were to deal with specific problems, or those of an emergency nature.
>
> "Presently, a substantial backlog of plans and specifications are awaiting the review of the engineering staff, and according to State Law these much needed projects cannot be placed under construction until the plans and specifications have received the Department's approval. Often, obvious mistakes are overlooked on the plans and specifications because of the hurried nature in which the review must be carried out.
>
> "The Division does a negligible amount of construction supervision. Also, the present operator training programs are not adequate to provide the quality of personnel necessary to operate public water and wastewater facilities.

> "In short, the Division of Sanitary Engineering is not providing the people of Tennessee the service charged to it under TCA Sections 53-2001 through 53-2008 because of insufficient personnel."

These statements were shown to be correct by the findings of the field survey phase of this evaluation. In addition to lack of inspections, other significant findings included unprotected sources of supply, deficient treatment facilities, deficient treatment operation, low pressures, and inadequate cross-connection control.

The primary need of the engineering phase of the Tennessee Water Supply Program is sufficient personnel effectively deployed throughout the State. Given sufficient personnel, a secondary need would be to reevaluate and redirect existing program activities. The lack of staff has necessitated compromises from optimum program practice which have accumulated over the years to the point that the entire program has been influenced. Not only are important program activities at times not performed, but due to lack of resources much work that is done lacks purpose and has become so routine as to be ineffective. Many engineering inspections are no more than "visits to the water plant". Return inspections to review compliance with program directives are seldom made. The problem extends beyond field visits and includes handling and follow-up of bacteriological reports, monthly operating reports, and other activities. The Division's report to the Environmental Health Committee, Tennessee State Health Planning Council dated February 19, 1970, summed the situation quite well by stating, "Obviously, the staff is inadequate and many important duties can only be performed in a perfunctory manner". Hence, the surveillance program as presently conducted has established a false sense of security regarding the reliability of water systems in Tennessee.

The engineering fluoridation control effort was also found to be lacking in necessary surveillance. Major deficiencies in facilities, equipment, and operational practices were found in water systems thought to be providing a dental health benefit to the people of Tennessee.

The attempt to establish a regional office for the eastern one-third of the State has not been fully implemented. The Knoxville Regional Office has never been equipped with adequate staff, office space or facilities to carry forth an effective regional program. This need has been documented in the Region's annual Progress Reports.

The operator training activity has reached a major portion of the water systems. Yet, field survey results show that many of the systems operated by trained personnel have significant deficiencies (See Appendix A, Table VI). Nine water systems (23 per cent of those surveyed) with short school trained operators produced water which did not meet the bacteriological standards at least once in the previous 12 months. Twenty-two (22) water systems (56 per cent of those surveyed) with short school trained operators were found to have Risk Factor of 3 or greater. Therefore, even with the great amount time, effort, and popularity of short school training, the program has not been effective in conveying the message of public health protection to the water supplies.

Public Health Service experience indicates that it takes an average of 1.2 man-days per public water supply to make a comprehensive field survey of facilities and operation. This time requirement for a single visit does not include making arrangements for field work or preparation of written reports of findings. Moreover, it does not include important follow-up work with local officials, developing programs for facilities improvement, or improving operator competence that are necessary if the surveys are to be an effective tool in securing adequate facilities and proper operation. It has been estimated[5] that, on the average, at least four man-days per year are required for each public water supply for plans review, meetings with governing bodies, surveys, report writing,

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/5 Community Water Supply Survey, 1969, p. 62.

training, etc. Cross-connection control activities are excluded from this estimate because this activity is primarily related to distribution system size. It is also estimated that "semi-public" water systems require approximately one-fourth as much time (one day per supply each year) as is required for public water supply surveillance.

The following assumptions were used to estimate the personnel requirements for the administration of an optimum water supply program for Tennessee.

1. 445 public water supply systems.
2. Four man-days/public water supply/year.
3. 800 "semi-public" water systems.
4. One man-day/"semi-public" supply/year.
5. Cross-connection control requirements for public water systems based on the following:

Population Served by System	Engineering Time Man-Days/System/Year
100,000 and over	5
10,000 to 99,999	3
1,000 to 9,999	2
Less than 1,000	1

6. 220 man-days equals one man-year.

Based on these assumptions, the annual personnel required are:

Public Water Supply: 445 systems x 4 $\frac{\text{Man-days}}{\text{System}}$ = 1,780 man-days

"Semi-Public" Water Supply: 800 systems x 1 $\frac{\text{Man-day}}{\text{System}}$ = 800 man-days

Cross-Connection Control:

Population	No. Systems	Man-Days System	Man-Days Group
100,000 and over	4	5	20
10,000 to 99,999	40	3	120
1,000 to 9,999	233	2	466
Less than 1,000	168	1	168
	445		774

The total annual personnel time for engineering activities is 3,354 man-days. This is equivalent to 15 man-years of professional time for the Tennessee Water Supply Program. This represents an increase of 11.5 man-years of professional time over the present engineering staff.

Laboratory

Bacteriological

Bacteriological sampling is an essential part of the Water Supply Program. The need for this activity in Tennessee was supported by the bacteriological quality findings of this study. Thirty-one (31) per cent of the supplies studied did not meet the bacteriological quality requirements of the Drinking Water Standards.

The primary needs of the bacteriological surveillance program are:

a. Consistent sampling of all public water supplies at the level prescribed by the Drinking Water Standards.

b. Evaluation and certification of all bacteriological laboratories that analyze drinking water.

c. Improved remedial action on unsatisfactory samples.

Consistent bacteriological sampling was not demonstrated by the findings of the study of water systems or the examination of laboratory records. This is primarily due to the fact that the Water Supply Program has not demanded that an adequate bacteriological sampling frequency be maintained. While the current program provides acceptable surveillance for small supplies serving less than 2,500 people, it does not provide a satisfactory check system for the larger supplies. Revision of the Water Supply Program's bacteriological sampling policy is indicated. It is recommended that the State laboratories examine monthly from each supply either (a) at least ten (10) per cent of the distribution system samples required by the Drinking Water Standards, or (b) two (2) samples, whichever is greater. Remaining samples required by the Drinking Water Standards should be analyzed in treatment plant laboratories certified by the State, or, in the case of small supplies without laboratory capability, in State laboratories.

Evaluation and certification of all laboratories examining bacteriological quality of drinking water is considered necessary for the proper operation of the Water Supply Program (See Sections 3.13 and 3.14 of Drinking Water Standards). The number of "official" samples could be increased by expanding the certification of water system laboratories. The Tennessee Laboratory Certification Program as provided by the Division of Laboratories is a cooperative effort within the Tennessee Department of Public Health. This program has certified all the Department of Health laboratories and eight other water system laboratories which are involved in the PHS Interstate Carrier Program. These laboratories, together with approximately one hundred (100) other laboratories requiring certification, place a great burden on the laboratory survey officer. This activity can only be handled by trained microbiologists.

An active program covering all water supply laboratories in the State will require the services of at least two survey officers plus associated clerical and records keeping staff. The Division of Laboratories has two survey officers who certify both water and milk laboratories. These officers, however, are not assigned full-time to this function, and essential clerical and records keeping staff are lacking. In order to examine and certify five State laboratories, 100 water plant laboratories, and other hospital, university, or commercial laboratories, it is essential that this be a full-time responsibility.

In order that the recommended bacteriological laboratory evaluations and certifications may be accomplished within a reasonable period of time, it is suggested that the State Branch Laboratories be integrated into the laboratory certification activity. The water treatment plant laboratories could be geographically grouped and initially visited by the Branch Laboratory Director or his delegated microbiologist. A communications link with water plant laboratories within each region would be established and determination of laboratories needing urgent attention could be made. Training and corrective action would be the joint responsibility of the Central and Branch Laboratories and would be accomplished on a priority schedule established by the initial screening. Once all existing bacteriological laboratories are certified, the program could be reasonably expected to be handled by the two Central Office Survey Officers. However, the communications link between the local laboratories and the branch laboratories should be continued in case immediate assistance is needed and to facilitate dissemination of new technical information.

Ineffective remedial action for unsatisfactory samples is primarily the result of lack of records keeping and notification. This need could be satisfied by the same clerical staff that assists the laboratory evaluation service. It is highly desirable that the time lag between laboratory results and notification be decreased. Telephone communication between the laboratory, the Water Supply Program, and the water supply appears to be the most desirable choice. This tri-party communication link is necessary in order that effective action can be initiated (resampling, engineering inspection, and analysis).

Chemical

The primary problem with chemical surveillance of public water supplies in Tennessee is the lack of laboratory facilities and personnel. The dependence of the Water Supply Program on the Stream Pollution Control Division for chemical laboratory support precludes a comprehensive drinking water surveillance program. The Stream Pollution Control Division has administrative jurisdiction over the laboratory, and its program will therefore be given top priority. The Water Supply Program cannot expect to accomplish its mission with a "we will do them if we have time" agreement from the laboratory. This is not to question the importance of the Stream Pollution Control Program, but to assert that the Water Supply Program should be accorded equal importance.

The second major problem is two-fold:

a. Water Supply Program regulations do not require routine sampling of drinking water for chemical quality.

b. Analyses of drinking water as presently performed do not include all constituents listed in the PHS *Drinking Water Standards*.

The following actions are proposed for improvement of this phase of the Water Supply Program:

a. The Water Supply Program should hire three chemists and one secretary to conduct the laboratory analyses necessary for surveillance of water supplies in Tennessee.

b. The Water Supply Program should establish a working agreement with the Stream Pollution Control Division that this work can be performed in the Stream Pollution Control Laboratory.

c. A working agreement should be made with the Division of Industrial Health and Radiological Health to analyze for radiochemical constituents in all water supplies.

d. Chemical analyses should include the constituents listed in the PHS *Drinking Water Standards* plus all other substances which have health significance (mercury and pesticides, for example).

e. Water samples from all drinking water supplies should be collected and analyzed according to the following recommended schedule unless more frequent analyses are indicated by the presence of excessive levels of certain harmful constituents:
   (1) Surface (river) - at least twice per year
   (2) Surface (lake) - at least once per year
   (3) Ground (well and spring) - at least once every three years.

f. The laboratory should provide more rigid quality control for the demineralized water used in analyses.

g. The laboratory should procure a more sensitive turbidimeter (Hach Model 2100 or equal) for drinking water analyses.

Data Processing

The successful administration of a water supply surveillance program requires the accumulation, processing, analysis and use of a vast quantity of information. In order to determine the best method of data processing for the Tennessee Water Supply Program, an estimation was made of the total amount of information that must be handled in one year. Four major areas of program responsibility were considered - bacteriological quality, chemical quality, engineering inspections, and monthly operating reports. It was assumed that each of these responsibilities would be carried out in accord with the PHS Drinking

Water Standards. As such, all 445 public water supplies would be sampled for bacteriological quality at the frequency consistent with Figure 1 of the Drinking Water Standards; all 445 public water supplies would be sampled for chemical quality of all constituents of the Drinking Water Standards; engineering inspections would be made on all 445 public water supplies using the State's Public Water Supply Rating Form; and monthly operating reports would be submitted by all 445 public water supplies. Using the above assumptions and further assuming frequency of chemical samples, engineering inspections, and completeness of monthly operation reports based on water supply source and/or treatment provided, it was determined that the Tennessee Water Supply Program must process 3.5 million items of information each year. This is a conservative estimate and does not include many other program aspects such as special water quality samples, engineering plans review, or surveillance of semi-public and individual water supplies.

The purpose of this discussion is to point out the immense quantity data that must be handled for the successful management of a Water Supply Program. If given proper attention, this activity will demand a great deal in terms of personnel, time, and space. Therefore, it appears evident that this activity should be reorganized under a computerized system and the services of a System Analyst should be secured. This system should utilize the State's Computer Center and be operated on a time sharing plan with other Divisions of the Tennessee State Department of Public Health. Automatic data processing would provide an effective and efficient means for evaluating water supply data. This important activity is now considered too time consuming for the experienced professional staff and is seldom given proper attention.

If the Water Supply Program is ever to be responsive to problems before they become critical, it must have the capability to define problems when they first become detectable. A computer can perform this important but time-consuming screening of data and can provide the professional staff with a periodic summation which designates potential problems. This will allow the engineering staff to concentrate on problem areas and begin immediate remedial action.

Resources

Organization

A few years ago the Division of Sanitary Engineering was the principal environmental health agency in the Tennessee Department of Public Health. At that time water supply rightfully received emphasis as one of the important programs within the Division. During the intervening years, however, a number of environmental program functions were transferred or otherwise removed from the Sanitary Engineering

Division, decreasing its overall prominence and the relative importance of its programs. In 1968, the Bureau of Environmental Health Services was created and superseded the Division of Sanitary Engineering as the primary environmental health agency of the Department. Under this organization, Air Pollution Control, Stream Pollution Control, Environmental Sanitation, and other important programs are also represented by Divisions within the Bureau. The ultimate effect of this was further de-emphasis of the Water Supply Program.

The importance of a strong Water Supply Program cannot be escaped. The health and life of every Tennessee resident and visitor depends upon the availability of safe drinking water. Because protection of drinking water is so crucial to a healthful environment, it should be elevated to its proper place as a separate identifiable Division within the Bureau of Environmental Health Services.

Personnel Requirements

Water Supply Program personnel requirements can be divided into two categories: those assigned to the proposed Division of Water Supply; and those assigned to supporting laboratory functions.

Although separate water supply laboratory facilities are desirable from an operation standpoint, in the interest of efficient and economical use of laboratory facilities, it is proposed that the Water Supply Program fund several water supply positions in the Division of Laboratories and in the Division of Stream Pollution Control Laboratory. As discussed in the preceding Activities Section, at least one secretarial and two bacteriologist positions are necessary for bacteriological laboratory certification and surveillance activities by the Division of Laboratories. (This makes no allowance for water analysis routinely performed by the Division of Laboratories). In addition, one secretarial and three chemist positions are necessary for water supply chemical surveillance by the Division of Stream Pollution Control Laboratory.

The minimum staff considered necessary to administer the proposed Division of Water Supply for an effective water supply program is 15 professional and 7 secretarial positions. These positions are recommended in addition to the 5 professional and 2 secretarial positions assigned to laboratory functions as discussed above. Also, it should be noted that this staffing level is designed to meet present needs and makes no allowance for increased needs of the future. In the interest of economy and for efficient use of sanitary engineering talent, engineering technician or other subprofessional personnel might be substituted for some of the professional staff. However, such substitution should be approached with caution and probably should not exceed 25 per cent of the overall (professional-subprofessional) staff.

The Division of Sanitary Engineering estimated in 1965 that establishment of a Knoxville Regional Office would save $6,304 annually (based on 1964 costs). This saving was based largely on travel expenses and personnel travel time required to cover the East Tennessee area from Nashville. Actually, benefits from decentralization amount to much more than this figure would suggest. Time formerly spent by central office staff prior to and during each trip in becoming reacquainted with the facilities, problems, and people of a distant location is largely saved. In addition, significant improvement can be made in quality of service provided, and in ability to quickly respond to problems and emergencies.

It is recommended that the proposed Division of Water Supply be further decentralized by fully staffing the Knoxville Regional Office and by establishing another Regional Office in Jackson to serve West Tennessee. Because the water supply problems in East Tennessee tend to be more difficult and more numerous than those in the western part of the State, it is recommended that the Knoxville Regional Office be staffed with no less than 3 sanitary engineers, 1 engineering technician, and 2 secretaries. It is recommended that the Jackson Regional Office begin operations with not less than one sanitary engineer, one engineering technician, and one secretary. It is further suggested that those placed in charge of the Regional Offices be appointed Assistant Directors.

A suggested staffing chart for the proposed Division of Water Supply is shown in Figure 4 .

In order that there may be a focal point within the program for coordination of important technical activities, it is proposed that certain senior staff members be designated technical consultants for specific subjects, such as Water System Design, Manpower Development and Training, Water System Operation, Distribution System Safety (cross-connection control), and Data Analysis. These consultants would be charged with the responsibility of keeping current in their respective specialities and providing assistance, training, and coordination of their particular activity throughout the State. They would be available to supplement other staff members efforts in difficult field or problem situations.

While Manpower Development could very well be a full-time job, other specialists might also be assigned general staff functions. Certain consultants could be stationed advantageously in one of the Regional Offices, especially if the region's unique problems demanded a disproportionate share of the consultants' time.

Budget Requirements

Personnel costs of the recommended Water Supply Program are estimated at approximately $330,000 based on current State salary levels. Travel, space, equipment and supplies may

FIGURE 4

PROPOSED STAFFING CHART

DIVISION OF WATER SUPPLY

Director

Jackson Office	Central Office	Knoxville Office
Assistant Director	Assistant Director	Assistant Director
1 - Engr. Technician	5 - San. Engineers	2 - San. Engineers
1 - Secretary	2 - Engr. Technicians	1 - Engr. Technician
	4 - Secretaries	2 - Secretaries

Other Related Water Supply Positions

Division of Laboratories
2 Bacteriologists and 1 Secretary

Division of Stream Pollution Control
3 Chemists and 1 Secretary

cost as much as $54,000[6] additional. These figures do not include bacteriological laboratory costs or indirect chemical laboratory costs but do include the new water supply positions proposed for the Division of Laboratories and the Division of Stream Pollution Control.

It is estimated that the Division of Laboratories examined about 25,000 water samples for bacteriological contamination in 1969. The cost of these analyses has never been calculated, nor has any cost been charged to the Water Supply Program. The analyses are conservatively estimated to have cost at least $50,000. Bacteriological analyses for the proposed program may number as high as 43,000 per year. This is about 18,000 more than are presently examined and could cost as much as $36,000 more than the current program.

It is also estimated that about 575 complete chemical analyses will be required each year for the proposed programs. Based on an estimated cost of $150.00[7] per sample and deducting chemical laboratory personnel costs already included above, the chemical samples may cost as much as $40,000. This would be about $33,000 more than is currently spent on these analyses.

/6 Community Water Supply Study p. 62.

/7 Community Water Supply Study p. 63.

The total estimated cost of the proposed Water Supply Program is summarized on the following table:

TABLE II
DIVISION OF WATER SUPPLY
PROPOSED BUDGET

Division of Water Supply Personnel	
15 professional & subprofessional and 7 secretaries	$253,000
Personnel assigned to Laboratories	
5 professional and 2 secretaries	77,000
Travel, Space, Equipment and Supplies	54,000
Indirect Laboratory Costs	
43,000 Bacteriological Samples	86,000
575 Chemical Samples	40,000
TOTAL	$510,000

The cost of the current Water Supply Program is estimated as:

Water Supply Activities	$ 69,500
Indirect Laboratory Costs	
25,000 Bacteriological Analyses	50,000
175 partial chemical analyses	7,000
TOTAL	$126,500

The proposed Water Supply Program amounts to a four-fold increase over what is now being spent for water supply protection. Viewed in another way, it may be said that the current program could not even qualify as a "half-way" measure, but only represents a "one-fourth" rate commitment to the essential task of protecting Tennesseean's drinking water.

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The following persons and/or agencies made a major contribution to the successful completion of this study.

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APPENDICES

A. Public Water Supply Survey Data

B. Semi-Public Water Supply Report

C. Individual Water Supply Data

D. Fluoride Practice

E. Water Supply Code and Regulations

F. Bacteriological Laboratory Survey

G. Waterborne Disease Occurrence

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APPENDIX A
TABLE I
PUBLIC WATER SYSTEMS STUDIED

NO	NAME OF SYSTEM	POPULATION SERVED	AVERAGE DAILY DEMAND (MGD)	SOURCE	TREATMENT /1
1	Belvidere U.D.	600	0.024	Well	D
2	Calderwood	79	0.007	First Cr.	FD
3	Camden	4,000	0.425	Tenn. R.	CSFDF1
4	Cedar Grove	1,000	0.045	2-Wells	ACSFD
5	Chattanooga	179,680	46.560	Tenn. R.	CSFDF1
6	Columbia	30,000	4.675	Duck R.	CSFDF1
7	Cookeville	16,600	2.580	Falling Water R.	CSFDF1
8	Cottage Grove	300	Unknown	2-Wells	None
9	Daisy-Soddy U.D.	7,500	0.480	Tenn. R. Wells	CSFD D
10	Dowelltown-Liberty	800	0.040	Well	D
11	Dyersburg	20,000	3.000	3-Wells	ACSFDF1
12	East Kingsport U.D.	5,000	0.200	Spring & Well Kingsport	D -
13	Eastside U.D.	35,000	3.230	Spring Chattanooga	D -
14	Elizabethton	15,000	2.500	Springs	DF1

TABLE I (Cont'd)

NO	NAME OF SYSTEM	POPULATION SERVED	AVERAGE DAILY DEMAND (MGD)	SOURCE	TREATMENT [1]
15	Hallsdale-Powell U.D.	20,000	1.500	Springs Beaver Cr.) Melton Res.)	D CSFD
16	Jackson	45,000	5.500	10-Wells 4-Wells 2-Wells	ADLF1P ACSFD ADL_A
17	Johnson City	50,000	6.500	Springs Watauga R. N. Indian Cr.	D ACSFDF1 CSFDF1
18	Knox-Chapman U. D.	10,500	0.680	French Broad R.	CSFD
19	Knoxville	190,000	29.000	Tenn. R. Third Cr. Wells & Spr.	CSFD CSFD CSFD
20	Lafayette	3,000	0.260	3-Springs	D
21	Memphis	620,000	82.600	140 Wells 5-Wells 4-Wells	AFD ACSFDF1 AFDF1
22	Mercer U. D.	300	0.006	Well	ADL_A
23	Mooresburg U. D.	250	0.030	Springs	D
24	Nashville	425,000	60.000	Cumberland R.	ACSFDF1
25	Orlinda	360	0.050	Spr. & Well	D
26	Orme	120	Unknown	Spring	None

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TABLE I (Cont'd)

NO	NAME OF SYSTEM	POPULATION SERVED	AVERAGE DAILY DEMAND (MGD)	SOURCE	TREATMENT /1
27	Pleasant Hill U. D.	400	0.020	Lake	ACSFD
28	River Road U. D.	400	0.016	Spr. & Lake	CSFD
29	Rogersville	5,500	0.475	Big Creek	CSFD
30	Sewanee	2,960	0.380	Lake	CSFDF1
31	Smith U. D.	2,000	0.380	Caney Fk. R.	CSFDF1
32	Spring Creek U. D.	220	0.015	2-Wells	D
33	Tri-Counties U. D.	400	0.240	Tenn. R.	CSFD
34	Tullahoma	18,000	1.500	Spring	CSFDF1
35	Turnbull U. D.	2,500	0.800	Turnbull Cr.	CSFD
36	Union City	10,000	2.000	4-Wells	ACSFDF1
37	Walland	100	0.040	Well	D
38	Waverly	(Deleted)			
39	West Point U. D.	300	0.010	2-Wells	DL_A
40	Whitwell	2,460	0.160	Sequatchie R.	CSFD
		1,725,329	148 gpcd Avg.		

/1 A - Aeration
C - Coagulation
S - Sedimentation
F - Filtration
D - Disinfection

L - Lime
L_A- Soda Ash
Fl- Fluoridation
P - Phosphates

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APPENDIX A

TABLE II

WATER QUALITY - PUBLIC WATER SYSTEMS

SYSTEM NO.	MONTHS BACTERIOLOGICAL STDS. NOT MET	CHEMICAL STANDARDS NOT MET*			
		RECOMMENDED		MANDATORY	
		Plant	Dist. Sys.	Plant	Dist. Sys.
1	1	0	0	0	0
2	0	Color (22.) Fe (0.540) Turb. (7.10)	Fe (0.630)	0	0
3	1	0	0	0	0
4	3	0	0	0	0
5	0	0	Fe (0.332) Mn (0.105 & 0.084)	0	Cr (0.058, 0.058 0.058& 0.059)
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	Fe (0.540)	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	Fe (0.465)	Fe (0.560 & 0.650)	0	0
12	0	0	0	0	0
13	0	0	0	0	0

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TABLE II (Cont'd)

SYSTEM NO.	MONTHS BACTERIOLOGICAL STDS. NOT MET	CHEMICAL STANDARDS NOT MET*			
		RECOMMENDED		MANDATORY	
		Plant	Dist. Sys.	Plant	Dist. Sys.
14	1	0	0	0	0
15	0	0	0	0	0
16	0	Mn (0.110)	Fe (0.440) Mn (0.240 & 0.390)	0	0
17	0	Color (20.) F (1.35) Fe (0.570) Mn (0.069) Turb. (20.)	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	F (1.35)	Fe (0.510)	0	0
22	1	0	0	0	0
23	3	Turb. (8.1)	0	0	0
24	0	0	0	0	0
25	0	Turb. (6.6)	Fe (0.424)	0	0
26	2	Turb. (6.3)	0	Cr (0.074)	0

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TABLE II (Cont'd)

SYSTEM NO.	MONTHS BACTERIOLOGICAL STDS. NOT MET	CHEMICAL STANDARDS NOT MET*			
		RECOMMENDED		MANDATORY	
		Plant	Dist. Sys.	Plant	Dist. Sys.
27	1	CCE (0.237)	0	0	0
28	0	-	-	-	-
29	0	0	0	0	0
30	0	0	0	0	0
31	1	0	0	0	0
32	0	0	0	0	0
33	0	Turb. (9.0)	0	0	0
34	0	0	0	0	0
35	1	0	0	0	0
36	0	F (1.35)	0	0	0
37	1	0	0	0	0
38	-	-	-	-	-
39	0	0	0	0	0
40	1	0	0	0	0
No. Not Meet. Stds.	12	13		2	
Per Cent	31%	33%		5.1%	

*Only those chemical constituents failing to meet Drinking Water Standards are shown. Color and Turbidity are expressed in Standard Units all other constituents expressed as mg/l.

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APPENDIX A
TABLE III
FACILITIES - PUBLIC WATER SYSTEMS

SYSTEM NO	SOURCE			TREATMENT		DISTRIBUTION			QUALITY CONTROL		RISK FACTOR /
	QUALITY	QUANTITY	PROTECTION	FACILITIES	OPERATION	STORAGE	PRESSURE	Cl_2 RESIDUAL	RECORDS	X-CONN. CONTROL	
1	OK	OK	OK	OK	X	OK	OK	X	OK	X	3
2	OK	OK	OK	X	X	OK	X	X	OK	P	4
3	OK	OK	OK	X	X	OK	X	X	OK	X	5
4	OK	OK	OK	X	X	OK	OK	X	OK	X	4
5	OK*	OK	X	UC	X	X	X	X	OK	X	7
6	OK	OK	X	OK	OK	OK	OK	X	OK	P	2
7	OK	X	X	X	X	X	OK	OK	OK	X	6
8	OK	OK	X	X	X		OK	-	X	X	5
9	OK	OK	X	X	X	OK	OK	OK	OK	X	4
10	OK	OK	OK	OK	OK	OK	OK	OK	OK	P	0
11	OK	OK	OK	X	X	X	OK	OK	OK	P	3
12	OK	OK	X	X	X	OK	OK	OK	X	X	5
13	OK	OK	OK	OK	OK	OK	OK	OK	OK	X	1
14	OK	UC	OK	X	X	X	X	OK	OK	X	6
15	OK	OK	OK	X	X	OK	OK	OK	OK		2
16	OK	OK	X	OK	X	X	OK	X	OK	OK	4

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TABLE III (Cont'd)

SYSTEM NO	SOURCE			TREATMENT		DISTRIBUTION			QUALITY CONTROL		RISK FACTOR/1
	QUALITY	QUANTITY	PROTECTION	FACILITIES	OPERATION	STORAGE	PRESSURE	Cl_2 RESIDUAL	RECORDS	X-CONN. CONTROL	
17	OK*	OK	X	X	X	OK[a]	OK	X	OK	X	5
18	OK	OK	OK	OK	OK	OK	OK	OK	X	X	2
19	OK*	OK	OK	OK	OK	OK	X	OK	OK	OK	1
20	OK	UC	OK	X	OK	X	OK	OK	OK	OK	3
21	OK	OK	OK	OK	X	OK	OK	OK	OK	X	2
22	OK	OK	OK	X	OK	OK[a]	OK	OK	X	X	3
23	OK	OK	OK	X	X	X	OK	X	X	X	6
24	OK	OK	OK	OK	OK	OK[a]	OK	OK	OK	OK	0
25	OK	OK	OK	X	OK	OK	X	OK	X	X	4
26	X	X	X	X	X	X	X	-	X	X	9
27	X	OK	OK	X	OK	OK	OK	OK	OK	OK	2
28	OK	OK	OK	X	OK	OK	OK	OK	OK	X	2
29	OK	OK	OK	OK	X	OK	OK	OK	OK	X	2
30	OK	OK	X	X	X	X	OK	OK	X	X	6
31	OK*	OK	X	X	X	OK	OK	OK	OK	P	3
32	OK	OK	OK	OK	X	OK	OK	X	X	X	4
33	OK	OK	X	X	OK	OK	OK	OK	OK	X	3

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TABLE III (Cont'd)

SYSTEM NO	SOURCE			TREATMENT		DISTRIBUTION			QUALITY CONTROL		RISK FACTOR/1
	QUALITY	QUANTITY	PROTECTION	FACILITIES	OPERATION	STORAGE	PRESSURE	Cl$_2$ RESIDUAL	RECORDS	X-CONN. CONTROL	
34	OK	OK	OK	OK	OK	OK	OK	X	OK	X	2
35	OK	OK	OK	X	X	OK	OK	OK	OK	X	3
36	OK	OK	X	X	X	X	OK	OK	OK	X	5
37	OK	OK	OK	X	OK	X	OK	OK	X	X	4
38	-	-	-	-	-	-	-	-	-	-	-
39	OK	OK	OK	OK	OK	OK	OK	OK	X	X	2
40	OK	OK		X	X	OK	X	OK	X	X	5
TOTAL "X"	2	4	13	26	24	11	8	11	12	28	
PER CENT	5%	10%	33%	67%	62%	28%	21%	30%	31%	72%	

* - Subject to upstream pollution
X - Deficient
/a - Conditional because of open reservoirs
P - Partial
UC - Under construction

/1 Judged on the ten facility items - "0" Facility deficiencies = least risk
"10" Facility deficiencies = most risk

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APPENDIX A

TABLE IV

PUBLIC WATER SUPPLY SURVEILLANCE

SYSTEM NO.	BACT. LABS.		NUMBER OF BACT. SAMPLES			MONTHS WITH NO SAMPLES	YEARS SINCE LAST	
	TYPE	CERTIFIED	REQUIRED[1/]	EXAMINED			SHD SURVEY	CHEMICAL ANAL.
				Avg.[2/]	Range/Month			
1	SHD	Yes	2	2	1-3	0	< 1	6
2	SHD	Yes	2	2	1-3	0	3	< 1
3	SHD-WTP	SHD Only	4	28	26-31	0	1	None
4	SHD	Yes	2	2*	0-7	2	< 1	None
5	SHD-WTP	Yes	160	162	160-164	0	3	< ½
6	SHD-WTP	SHD Only	35	22	14-25	0	1	< 1
7	SHD-WTP	SHD Only	20	15	11-18	0	> 1	> 3
8	SHD	Yes	2	1	1-1	0	< 1	> 31
9	SHD-WTP	SHD Only	8	4	2-10	0	1	> 8
10	SHD	Yes	2	2	1-2	0	1	11½
11	SHD-WTP	SHD Only	24	27	15-30	0	1½	> 5
12	SHD	Yes	5	1	0-2	1	4	> 5

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TABLE IV (Cont'd)

SYSTEM NO.	BACT. LABS.		NUMBER OF BACT. SAMPLES			MONTHS WITH NO SAMPLES	YEARS SINCE LAST	
	TYPE	CERTIFIED	REQUIRED 1/	EXAMINED			SHD SURVEY	CHEMICAL ANAL.
				Avg. 2/	Range/Month			
13	SHD	Yes	42	2	2-2	0	1	5
14	SHD	Yes	18	3	1-11	0	> 3	> 11
15	SHD-WTP	SHD Only	24	20	16-20	0	3½	> 5
16	SHD-WTP	SHD Only	60	10	—	0	1	< 1
17	SHD-WTP	Yes	60	31	26-63	0	< 1	< 1
18	SHD-WTP	SHD Only	15	2	1-2	0	3½	None
19	SHD-WTP	Yes	160	175	170-185	0	< 1	< 1
20	SHD	Yes	3	1½	1-2	0	> 1	5
21	SHD-WTP	Yes a/	250	422	325-515	0	< 1	½
22	SHD	Yes	2	3	1-5	0	1	None
23	SHD	Yes	2	1	0-4 b/	8	3	> 5
24	SHD-WTP	Yes	230	414	383-466	0	< 1	< 1
25	SHD	Yes	2	2	2-2	0	< ¼	> 6

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TABLE IV (Cont'd)

SYSTEM NO.	BACT. LABS.		NUMBER OF BACT. SAMPLES			MONTHS WITH NO SAMPLES	YEARS SINCE LAST	
	TYPE	CERTIFIED	REQUIRED[1/]	EXAMINED			SHD SURVEY	CHEMICAL ANAL.
				Avg.[2/]	Range/Month			
26	SHD	Yes	2	½	0-4	10	½	7
27	SHD	Yes	2	2*	0-4	1	½	None
28	SHD	Yes	2	1	0-2	6	1	None
29	SHD-WTP	SHD Only	6	32	30-32	0	> 2	> 4
30	SHD	Yes	3	2	1-2	0	½	> 6
31	SHD	Yes	2	2	1-5	0	> 1	> 6
32	SHD	Yes	2	1	0-3	2	2	None
33	SHD	Yes	2	2	1-3	0	1½	5
34	SHD-WTP	SHD Only	20	32	30-33	0	1	9
35	SHD-WTP	SHD Only	4	2	1-5	0	1½	7
36	SHD-WTP	SHD Only	13	32	30-34	0	1½	> 3
37	SHD	Yes	2	2	1-3	0	1	31
38	-	-	-	-	-	-	-	-

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TABLE IV (Cont'd)

SYSTEM NO.	BACT. LABS.		NUMBER OF BACT. SAMPLES			MONTHS WITH NO SAMPLES	YEARS SINCE LAST	
	TYPE	CERTIFIED	REQUIRED[1]	EXAMINED Avg.[2]	EXAMINED Range/Month		SHD SURVEY	CHEMICAL ANAL.
39	SHD	Yes	2	2	1-3	0	½	None
40	SHD	Yes	3	2	1-3	0	½	None
				#Deficient = 21			#> 1 = 16	#> 3 = 31
				54%			41%	80%

SHD - State Health Department

WTP - Water Treatment Plant

a/ - WTP only provisionally certified

b/ - Some samples were Special

* - See months with no samples

1/ Minimum number of samples required to meet Drinking Water Standards.

2/ Average number of samples examined per month during the 12 month period preceding the study.

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APPENDIX A

TABLE V

SUMMARY OF PUBLIC WATER SYSTEM DEFICIENCIES

SYSTEM NO	WATER QUALITY /1	RISK FACTOR /2	SURVEILLANCE			LAST STATE RATING /3
			Bact.	Chem.	SHD	
1	B	3	OK	X	OK	67
2	C	4	OK	OK	X	85
3	B	5	OK	X	OK	89
4	B	4	X	X	OK	Not Rated
5	C & C*	7	OK	OK	X	92
6	OK	2	X	OK	OK	98
7	OK	6	X	X	X	90
8	C	5	X	X	OK	62
9	OK	4	OK	X	OK	95
10	OK	0	OK	X	OK	83
11	C	3	OK	X	X	92
12	OK	5	X	X	X	86
13	OK	1	X	X	OK	88
14	B	6	X	X	X	97
15	OK	2	X	X	X	94
16	C	4	X	OK	OK	94
17	C	5	X	OK	OK	90
18	OK	2	X	X	X	98
19	OK	1	OK	OK	OK	98
20	OK	3	X	X	X	90
21	C	2	OK	OK	OK	93
22	B	3	OK	X	OK	60

TABLE V (Cont'd)

SYSTEM NO	WATER QUALITY /1	RISK FACTOR /2	SURVEILLANCE Bact.	SURVEILLANCE Chem.	SURVEILLANCE SHD	LAST STATE RATING /3
23	B & C	6	X	X	X	47
24	OK	0	OK	OK	OK	97
25	C	4	OK	X	OK	78
26	B, C & C*	9	X	X	OK	16
27	B & C	2	X	X	OK	86
28	OK	2	X	X	OK	Not Rated
29	OK	2	OK	X	X	90
30	OK	6	X	X	OK	90
31	B	3	OK	X	X	88
32	OK	4	X	X	X	Not Rated
33	C	3	OK	X	X	77
34	OK	2	OK	X	OK	96
35	B	3	X	X	X	90
36	C	5	OK	X	X	99
37	B	4	OK	X	OK	30
38	-	-	-	-	-	-
39	OK	2	OK	X	OK	69
40	B	5	X	X	OK	90
TOTAL NO.	22	37	20	31	16	
PER CENT	56%	95%	51%	80%	41%	

/1 B - Exceeded Bacteriological Standard at least once in 12 months.
C - Exceeded at least one "recommended" chemical limit.
C*- Exceeded at least one "mandatory" chemical limit.

/2 Judged on ten facilities items "0" deficiencies = least risk
"10" deficiencies = most risk

/3 Approved Water System = 90 rating or better.

X = Inadequate or deficient

APPENDIX A

TABLE VI

PUBLIC WATER SUPPLY OPERATORS AND OPERATION

SYSTEM NO	OPERATOR FULL TIME	OPERATOR TRAINING	OPERATOR CERTIFIED	WATER QUALITY	RISK FACTOR /1
1	No	On-the-Job	No	B	3
2	No.	Short School	No	C	4
3	Yes	Short School	No	B	5
4	No	On-the-Job	No	B	4
5	Yes	College	Yes	C & C*	7
6	Yes	Short School	Yes	OK	2
7	Yes	Short School	Yes	OK	6
8	No	On-the-Job	No	C	5
9	Yes	Short School	Yes	OK	4
10	No	Short School	Yes	OK	0
11	Yes	Short School	Yes	C	3
12	Yes	Short School	Yes	OK	5
13	Yes	Short School	Yes	OK	1
14	Yes	Short School	Yes	B	6
15	Yes	Short School	No	OK	2
16	Yes	Short School	Yes	C	4
17	Yes	Short School	Yes	C	5
18	Yes	Short School	Yes	OK	2
19	Yes	College	Yes	OK	1
20	Yes	Short School	Yes	OK	2
21	Yes	College	Yes	C	2
22	No	Short School	No	B	3
23	No	Short School	No	B & C	6

SYSTEM NO	OPERATOR FULL TIME	OPERATOR TRAINING	OPERATOR CERTIFIED	WATER QUALITY	RISK FACTOR /1
24	Yes	College	Yes	OK	0
25	No	Short School	Yes	C	4
26	None	---	---	B, C & C*	9
27	No	Short School	Yes	B & C	2
28	No	On-the-Job	No	OK	2
29	Yes	Short School	Yes	OK	2
30	Yes	Short School	Yes	OK	6
31	Yes	Short School	Yes	B	3
32	No	On-the-Job	No	OK	3
33	No	Short School	Yes	C	3
34	Yes	Short School	Yes	OK	2
35	Yes	Short School	Yes	B	3
36	Yes	Short School	Yes	C	5
37	No	Short School	No	B	4
38	-	---	---	---	---
39	No	Short School	No	OK	2
40	Yes	Short School	Yes	B	5
SUMMARY	14-No 36%	29 S.Sch.- 76% 5 Job - 13% 4 College-11%	13-No 33%	22-Problems 56%	3.5 Average

/1 Judged on ten facilities items "0" deficiencies = least risk
"10" deficiencies = most risk

WATER QUALITY

B - Exceeded Bacteriological Standard at least once in 12 months.
C - Exceeded at least one "recommended" chemical limit.
C*- Exceeded at least one "mandatory" chemical limit.

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APPENDIX B

TENNESSEE SEMI-PUBLIC WATER SUPPLIES

Supervision of public water supplies by the Tennessee Department of Public Health has been extended, under past administrative policies, only to supplies with 25 or more connections. It is obvious, however, that many supplies serving fewer than 25 customers could constitute major threats to public health. There are also many water systems serving the public at a variety of private and commercial establishments, such as restaurants, motels, subdivisions, trailer courts, parks, recreation areas, etc. The term "semi-public" water supply has been used to describe these supplies which are not included in a formal surveillance program. Little information was available in State Health Department files regarding number of these supplies, number of persons served, and extent of public health protection provided. A recent compilation by the Department supplemented existing information, but significant gaps in knowledge remained. Because it had become apparent the "semi-public" water supplies influenced the health of many people, they were included in the Tennessee Water Supply Study.

In order to evaluate the present condition of Tennessee "semi-public" water supplies and to ascertain if additional health agency surveillance may be necessary to assure protection of the public health, three counties were selected to be surveyed and sampled. These counties were Sevier County in east Tennessee, Wilson County in mid-Tennessee, and Fayette County in west Tennessee. Although the sample was admittedly small, it was felt that conclusions drawn from these three counties could reasonably be extended to generally describe the condition of "semi-public" water supplies in Tennessee.

Sevier County consists of rolling to mountainous terrain, including the Great Smoky Mountains and the extensive tourist development in that vicinity. Wilson County is somewhat flatter and is bordered on the northeast by Old Hickory Lake, an impoundment on the Cumberland River. Fayette County is essentially flat and predominantly agricultural.

"Semi-public" water supplies in the three counties are largely dependent on groundwater for source of supply. Wilson County, and to a lesser degree Sevier County, are underlaid with limestone formations which are subject to fracture and solution channels and which may allow extensive movement of contaminated groundwater. This geologic condition may cause properly constructed and operated wells to yield contaminated water. Fayette County is underlaid with a massive sand aquifer yielding water of excellent quality.

The study attempted to establish an estimate of the number of persons affected by "semi-public" water supplies in the State. In many cases, the number of persons actually served by a supply was not recorded. In addition, the probability that water would be consumed differs between guests at a motel and visitors at a day facility such as an amusement park. Nevertheless, visitors to both facilities are dependent upon the water served as the only water available. All visitors were included, therefore, in defining the population at risk. Assumptions employed in obtaining the estimated population at risk are included at the end of this Appendix.

Table I presents a tabulation of the principle features of the "semi-public" water supplies surveyed in the three-county area. This tabulation includes information on the number of people served, source, treatment provided, surveillance by health agency, and quality of water produced. Also included is a rating of the overall acceptability of the system from the public health standpoint. Obviously some judgment was necessary to rate the adequacy of treatment and freedom from sanitary defects. However, emphasis in rating the systems was placed upon results of bacteriological testing and presence of chlorinating equipment and chlorine residual. Sufficient data were not assembled to evaluate adequately whether or not a particular water supply could be operated safely without disinfection. In this report, therefore, disinfection is necessary for a supply to be considered fully satisfactory. Supplies considered "satisfactory" in all other respects except for the absence of chlorine equipment or chlorine residual were considered "questionable".

In order to provide satisfactory public health protection, it is the policy of the Tennessee State Department of Public Health to require disinfection of all public water supplies. The U. S. Public Health Service also endorses disinfection of all public water supplies.

TABLE I - SUMMARY OF PRINCIPLE FEATURES OF SUPPLIES SURVEYED

	POPULATION SERVED		SOURCE			TREATMENT			SURVEILLANCE	QUALITY			RATING		
WILSON COUNTY SUPPLY	Est. Daily Pop. at Risk	Est. Annual Pop. at Risk	Adeq. Qty.	Type	Free From Visible Sanitary Defect	Equip. to Chlor.	Chlor. Resid. Detect.	Addit.* Treat.	Health Agcy. Visit In Prev. 2 Yrs.	Total Coli.	Fecal Coli.	Esthetic Accept.	Satis.	Ques.	Unsatis
Bentleys Boat Dock	50	360	Yes	W	No	Yes	2.0	-	Yes	0	0	Yes		X	
Boxwell Reservation	750	4,800	Yes	Surf	Yes	Yes	0	DCSF	Yes	0	0	Yes		X	
Cedar Creek Club #1	52	52	Yes	W	Yes	Yes	0	Soft.	Yes	270	130	Yes			X
Cedar Creek Club #2	63	1,800	Yes	W	Yes	Yes	0	Soft.	Yes	23	4	Yes			X
Cherokee Resort	370	11,610	Yes	3 W	Yes	Yes	0.3	-	Yes	0	0	Yes	X		
Easter Seal Camp	110	704	Yes	Surf	Yes	Yes	3.0	CSF	No	0	0	Yes	X		
Maple Hill Trailer Park	6	6	Yes	W	No	Yes	0	-	No	20	4	Yes			X
Minit Burger	180	13,500	Yes	Surf	No	Yes	0	F_p	Yes	670	10	Yes			X
Murphy Subdivision	50	50	Yes	Surf	Yes	Yes	0	DCSF	No	0	0	Yes		X	
Pebble Point Subdivision	28	28	Yes	Surf	Yes	Yes	UK	FDF_p	No	0	0	Yes	X		
Rancho 70 Mobile Home Park	28	28	Yes	W	Yes	Yes	0.7	-	Yes	0	0	Yes	X		
Ruilman Center	100	640	Yes	W	Yes	Yes	0	-	Yes	0	0	Yes		X	
Spencers Creek Spa	184	5,400	Yes	W	No	Yes	0.2	F_p	Yes	30	4	Yes			X
TOTAL	1,965	38,950													
FAYETTE COUNTY SUPPLY															
Ames Club House	300	1,200	Yes	W	Yes	No		-	No	0	0	Yes		X	
Arlington Mobile Park	210	210	Yes	2 W	Yes	No		-	Yes	0	0	Yes		X	
C & R Truck Stop	212	1,057	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Camp Pine Crest	53	320	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Drexel's Restaurant	247	18,000	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
E & E Restaurant	210	15,750	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
La Grange	210	210	Yes	2 W	Yes	No		-	No	0	0	Yes		X	
Meadow Subdivision	35	35	Yes	W	Yes	No		-	No	0	0	Yes		X	
Middlecoff Trailer Park	63	63	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Pine Lake Mobile Estates	149	149	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Wards Trailer Court	52	52	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Wm. Jordan Subdivision	21	21	Yes	W	Yes	No		-	No	2	0	Yes		X	
TOTAL	1,762	37,067													

*See Explanation of Symbols Below

TABLE I - SUMMARY OF PRINCIPLE FEATURES OF SUPPLIES SURVEYED

SEVIER COUNTY SUPPLY	POPULATION SERVED		SOURCE			TREATMENT			SURVEILLANCE	QUALITY			RATING		
	Est. Daily Pop. at Risk	Est. Annual Pop. at Risk	Adeq. Qty.	Type	Free From Visible Sanitary Defect	Equip. to Chlor.	Chlor. Resid. Detect.	Addit.* Treat.	Health Agcy. Visit In Prev. 2 Yrs.	Total Coli.	Fecal Coli.	Esthetic Accept.	Satis.	Ques.	Unsatis.
Bible Presby. Camp	42	269	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Buena Vista Estates #1	7	7	Yes	W	Yes	No		-	No	0	0	Yes			X
Buena Vista Estates #2	7	7	Yes	W	Yes	No		-	No	0	0	Yes		X	
Camp Ba Yo Ca	125	800	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Camp 'n' Air #1	80	3,200	Yes	W	Yes	No		-	Yes	12	0	Yes			X
Camp 'n' Air #2	80	3,200	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Camp Pigeon Forge	104	4,160	Yes	W	Yes	Yes	0.2	-	Yes	0	0	Yes	X		
Camp Smoky	230	9,200	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Delozier Motel	27	1,295	Yes	W	Yes	Yes	0	-	Yes	0	0	Iron		X	
Douglas Bait Center	40	4,500	Yes	W	Yes	Yes	0.3	-	Yes	0	0	Yes	X		
Flat Branch Court	15	648	Yes	W	Yes	Yes	0.9	-	Yes	56	20	Iron	X		
Gatlinburg Ski Corp.	1,500	180,000	Yes	W	No	No		-	Yes	0	0	Iron			X
Gatlinburg Tr. Pk. and Campgr.	154	6,160	Yes	Sp	Yes	Yes	0.3	-	Yes	4	0	Yes		X	
Greenbriar Island Campgr.	230	9,200	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Greenbriar Motel	14	1,296	Yes	W	Yes	Yes	0	-	Yes	0	0	Iron		X	
Goldrush Junction	660	79,200	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Hillside Motel	14	1,296	Yes	W	Yes	Yes	0.5	-	Yes	0	0	Sand	X		
J. B. Whaley Store	60	450	Yes	W	Yes	Yes	0	-	Yes	20	4	Yes		X	
L-Ranch Motel	20	1,782	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Li'l Bit of Heaven #1	7	7	Yes	W	No	No		-	Yes	0	0	Iron			X
Li'l Bit of Heaven #2	10	10	Yes	W	Yes	No		-	Yes	0	0	Iron		X	
Li'l Ponderosa	133	5,360	Yes	W	Yes	No		Fp	Yes	0	0	Yes		X	
Mountain View Trailer Park	49	49	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Norton Creek Club	14	14	Yes	Sp	Yes	No		-	Yes	700	2	Yes		X	
Oak Hill Motel	9	972	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Our Place Campground	86	3,440	Yes	W	Yes	No		-	Yes	96	2	Yes			X
Parkway Motel	24	1,790	Yes	W	Yes	Yes	0	-	Yes	0	0	Yes		X	
River Edge Camp	170	6,800	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Ski Mountain Motel	20	1,460	Yes	W	Yes	Yes	0	-	Yes	0	0	Yes		X	
Smoky Mtn. Private Camp	44	1,600	Yes	W	Yes	No		-	Yes	0	0	Yes		X	

TABLE I - SUMMARY OF PRINCIPLE FEATURES OF SUPPLIES SURVEYED

SEVIER COUNTY SUPPLY	POPULATION SERVED		SOURCE			TREATMENT			SURVEILLANCE	QUALITY			RATING		
	Est. Daily Pop. at Risk	Est. Annual Pop. at Risk	Adeq. Qty.	Type	Free From Visible Sanitary Defect	Equip. to Chlor.	Chlor. Resid. Detect.	Addit.* Treat.	Health Agcy. Visit In Prev. 2 Yrs.	Total Coli.	Fecal Coli.	Esthetic Accept.	Satis.	Ques.	Unsatis.
Spring Valley Camp	154	6,160	Yes	W	Yes	Yes	0.2	-	Yes	0	0	Yes	X		
Trout Creek Cam & Tr. Pk.	160	6,400	Yes	W	Yes	Yes	0.1	-	Yes	28	0	Yes		X	
Venture Out	318	12,720	Yes	W	Yes	Yes	3.0	-	Yes	0	0	Yes	X		
Village Mgmt - Alpendorf	262	262	Yes	W	Yes	No		-	No	0	0	Yes		X	
Village Mgmt - Tyrolea	175	175	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Wa-Floy Motel	48	5,184	Yes	W	Yes	No		-	Yes	0	0	Iron		X	
Waldens Creek Pres. Camp	400	2,560	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Waldens Creek Trailer Ct.	49	49	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
Webbs Creek Camp	70	2,800	Yes	W	Yes	No		-	Yes	0	0	Yes		X	
TOTAL	5,616	364,482													

Treatment Symbols*

C = Chemical Coagulation
D = Prechlorination
F = Gravity Sand Filtration
F_p = Pressure Filtration
S = Sedimentation
UK = Information Unknown

Since the differentiation between public and "semi-public" supplies has been largely one of size, it is felt that public health requirements for "semi-public" supplies should provide essentially the same level of protection.

Conclusions

1. Based on estimates derived from data obtained during the study, approximately 800 "semi-public" water supplies are operating in Tennessee. An estimated 3.8 million persons annually are dependent in one or more instances on "semi-public" water supplies for drinking water. This significant number of persons who are or may be affected by the quality of the water requires that a program for supervision of these supplies be established.

2. Of 64 "semi-public" water supplies surveyed and sampled, a significant percentage revealed the presence of bacteriological contamination. Twenty (20) per cent showed the presence of coliform organisms (19 per cent failed the bacteriological standard), and 14 per cent showed the presence of fecal coliform organisms.

3. Only 16 per cent of the "semi-public" water supplies surveyed and sampled could be given an overall "satisfactory" rating.

4. Seventeen (17) per cent of the supplies surveyed had not been visited by a health agency official in the previous two years. Most health agency surveillance was provided by county sanitarians who are not fully trained in maintenance and operation of water

treatment facilities. In most cases, the visit consisted of collection of a water sample and did not include significant inspection of facilities or operational practices.

Recommendations

1. Under authority granted in Section 53-2001, Tennessee Code Annotated, include all supplies serving the public under present and future public water supply programs.

2. Provide minimum standards for construction, including protection of source, size and type storage facility, disinfection equipment, and distribution system.

3. Provide for initial plan review and approval, inspections of facilities and operations at least annually, and a bacteriological sampling program which provides for submission of at least two samples monthly for all supplies serving the public.

4. Require mandatory disinfection of all water supplies serving the public.

Assumptions for Calculating Annual Population at Risk

1. Family campgrounds and travel trailer parks operate 120 days per year at 50 per cent of capacity. Average length of stay is three days per family with an average of four (4) visitors per family.

2. Church camps and similar institutions operate eight sessions at 80 per cent capacity.

3. Tourist and truck stop restaurants operate 300 days per year. Daily customers average six times seating capacity and customers average four visits per year.

4. Lunch counters are open 300 days per year. Customers average four times seating capacity and average 40 visits per year.

5. Evening meal only restaurants located in recreation areas average 120 days per year operation. Daily customers average one per seat capacity and customers return an average of four times per year.

6. Amusement parks operate 120 days a year at 30 per cent of peak day patronage. No customers return.

7. Trailer parks and subdivisions risk only residents.

8. Motels operate 180 days a year at 60 per cent capacity. The average customer (3 people) stays two days. (All motels in study were tourist-oriented.)

9. Club houses are occupied to capacity four times per year.

Calculations of Annual Population at Risk

In Sevier County, the estimated annual population at risk was divided by the number of supplies surveyed, yielding approximately 9300 persons at risk annually per supply. A similar calculation for Wilson and Fayette Counties yields 3,000 and 3,100 persons at risk annually, respectively. Averaging these three figures yields approximately

5,000 persons annually at risk per "semi-public" supply.

Based on the inventory of "semi-public" supplies assembled by the Tennessee State Department of Public Health from lists submitted by county sanitarians, there are an average of approximately 6.5 supplies per county. During the survey, it was found that approximately 20 per cent more supplies were found than were included on the county sanitarians' original listing. Based on this observation, it is estimated that each county averages eight (8) "semi-public" water supplies.

Ninety-five (95) counties with eight (8) supplies serving 5,000 persons annually comes to 3,800,000 persons whose health may be affected by "semi-public" water supplies each year.

APPENDIX C

INDIVIDUAL WATER SUPPLY SURVEY

STATE OF TENNESSEE

Summer 1970

PRELIMINARY ANALYSIS OF RESULTS

BACTERIOLOGICAL QUALITY OF WATER

Springs:

Grainger County
Number of springs reported: 39
Number showing presence of fecal coliform: 33 (85%)
Number showing presence of total coliform in concentrations of four or more/100ml: 38 (97%)

Rutherford County
Number of springs reported: 1 (positive for both fecal and total coliform)

Haywood County
Number of springs reported: 1 (positive for both fecal and total coliform)

Wells:

Grainger County
Number of wells reported: 123
Number showing presence of fecal coliform: 49 (40%)
Number showing presence of total coliform in concentrations of four or more/100ml: 57 (46%)

Rutherford County
Number of wells reported: 192
Number showing presence of fecal coliform: 102 (53%)
Number showing presence of total coliform in concentrations of four or more/100ml: 160 (83%)

Haywood County
Number of wells reported: 199
Number showing presence of fecal coliform: 48 (24%)
Number showing presence of total coliform in concentrations of four or more/100ml: 68 (34%)

Cisterns:

Grainger County
Number of cisterns reported: 16
Number showing presence of fecal coliform: 9 (56%)
Number showing presence of total coliform in concentrations of four or more/100ml: 11 (69%)

Rutherford County
Number of cisterns reported: 0

Haywood County
Number of cisterns reported: 0

Observations on bacteriological quality.

Haywood County's wells produce higher quality water because of the unconsolidated formations (sand and gravel) in which they are constructed. The effectiveness of sand as a barrier to bacterial travel is not as apparent from the data above as it would be with better well construction. The drilled wells produced much better water, on the average, than the bored wells; the latter are seen to be severely contaminated (see following paragraphs). It is much easier to construct a safe well in unconsolidated formations than in consolidated ones, such as the limestones of Rutherford and Grainger Counties.

WELL CONSTRUCTION AND BACTERIOLOGICAL QUALITY.

Grainger County
Dug wells reported: 2
Number showing presence of fecal coliform: 2 (100%)
Number showing presence of total coliform in concentrations of four or more/100ml: 2 (100%)

Bored wells reported: 9
Number showing presence of fecal coliform: 4 (44%)
Number showing presence of total coliform in concentrations of four or more/100ml: 6 (67%)

Driven wells reported: 0

Drilled wells reported: 109
Number showing presence of fecal coliform: 43 (39%)
Number showing presence of total coliform in concentrations of four or more/100ml: 52 (48%)

Rutherford County
Dug wells reported: 1 (contaminated with both)

Bored wells reported: 0

Driven wells reported: 0

Drilled wells reported: 186
Number showing presence of fecal coliform: 101 (54%)
Number showing presence of total coliform in concentrations of four or more/100ml: 159 (85%)

Well construction details and sanitary defenses. In addition to the geology, factors which influence the safety of well source include:

1) Method of construction (driven, bored, drilled, etc.)
2) Quality and amount of casing installed.
3) Kind and extent of sealing the casing into the formation--especially in the upper layers.
4) Presence of contaminant-proof well cover.
5) Exposure of the well to flooding.
6) Presence of a pit around the well.
7) Kind of pump installation.

Generally speaking, quality of well construction in all three counties is so poor, that one or more deficiencies threatening the safety of the source could be found in nearly every well. Even in those wells where a cement formation seal around the casing was reported (about one well in four in Rutherford County), the method of placement and the extent of sealing was unknown.

Common sense would seem to dictate that some effort should be made at every well to prevent the entry of contaminants from the surface either through the annular space around the casing, or directly into the well at the top. Yet, the data show that very few wells have both of these avenues effectively closed off. This is especially true in the limestone rock formations of Rutherford and Grainger Counties, where wells are particularly vulnerable to pollution through an unsealed annular space around the casing.

The only analysis of data so far which has pointed to clues as to the sources of contamination is one in which the twelve most highly contaminated wells (using fecal contamination as the index) in Rutherford County were compared with twelve of the wells from the same county which showed no contamination whatever. These "safe" wells were selected at random from the 24 "safe" wells for which data were complete. This comparison showed that:

1) the most contaminated wells without acceptable covers were 2½ times more numerous than were the "safe" wells.

2) there were five hand pumps used in the contaminated group, compared with only one in the "safe" group.

In addition, the average depth of the highly contaminated wells was 77 feet, while the average depth of the "safe" wells was 110 feet. This does not mean, of course, that safety can be obtained only by drilling deeper. Drilling deeper here could have meant that more casing in the hole provided more probability that the annular space would seal itself; or that the water source itself was deeper, providing more natural filtration by the upper earth formations.

The average age of the highly contaminated wells was estimated at 20 years, while that for the "safe" wells was estimated at 15 years. If significant, this could mean that corrosion of the casing is permitting contamination from the surface, or it could simply reflect a better quality of workmanship and/or casing in more recent years.

CHEMICAL QUALITY OF WATER

Springs:

Grainger County
    Number of springs reported: 39
    Number showing concentrations exceeding recommended limits: 4 (Zn 1; Fe 2; and Mn 1)
    Number showing concentrations exceeding mandatory limits: none.

Rutherford County
    Number of springs reported: one (no limits exceeded)

Haywood County
    Number of springs reported: one (no limits exceeded)

Wells:

Grainger County
    Number of wells reported: 123
    Number showing concentrations exceeding recommended limits: 31 (Fe 21; Mn 7; Zn 2; and Cu 1)
    Number showing concentrations exceeding mandatory limits: 3 (Ba 1; Pb 1; and Ag 1)

Rutherford County
    Number of wells reported: 192
    Number showing concentrations exceeding recommended limits: 59 (Fe 40; Mn 17; and F 2)*
    Number showing concentrations exceeding mandatory limits: 5 (Cr 1; Pb 2; and Ag 2)

Haywood County
Number of wells reported: 199
Number showing concentrations exceeding recommended limits: 55 (Fe 35; Mn 12; NO_3 1; Zn 2; Cu 5)*
Number showing concentrations exceeding mandatory limits: 3 (Pb 3)

Cisterns:

Grainger County
Number of cisterns reported: 16
Number showing concentrations exceeding recommended limits: 2 (Fe 1; Mn 1)
Number showing concentrations exceeding mandatory limits: none

Rutherford County
Number of cisterns reported: none

Haywood County
Number of cisterns reported: none

Summary:

Number of systems: 571**
Approximate number of people served: 2,850
Average Number of persons per supply: 5

Preliminary analysis of the rural, individual water supply data indicates that the vast majority of people utilizing rural water systems in three Tennessee counties are drinking water of inferior quality.

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* Only 38 analyses run for fluoride and nitrate on the 571 sources.

** The actual number of water systems surveyed was 576. However, for purposes of this preliminary report, complete data was available on only 571.

(1) Fifty-nine (59) per cent of the rural systems had water of poor bacteriological quality. The approximate exposed population is 1,680.

(2) Twenty-six (26) per cent of the rural systems had water of aesthetically inferior chemical quality. The approximate exposed population is 740.

(3) Two (2) per cent of the rural systems had water of such chemical quality to pose a direct threat to human health. The approximate exposed population is 57.

There has been sufficient analysis to relate the quality of well construction with the poor bacteriological quality found in many rural systems. Construction deficiencies were found in nearly every installation. Further analysis is continuing on chemical quality and the other findings of the study.

The study of rural, individual water systems in Tennessee is part of a national study of rural water supplies by the Bureau of Water Hygiene. A special report highlighting this important area of water supply will be published at a later date.

TENNESSEE WATER SUPPLY PROGRAM EVALUATION
ADEQUACY OF FLUORIDATION AT SELECTED WATER SUPPLY SYSTEMS IN TENNESSEE

Introduction

The Tennessee Department of Public Health recommends the fluoridation of all public water supplies in the State to a level of 0.8 - 1.2 mg/l as an important public health measure for the prevention of tooth decay. The Division of Sanitary Engineering of the Department of Public Health has been charged with the responsibility to: "determine the adequacy of equipment and proposed technical supervision," and to "advise local officials concerning details of the treatment and laboratory procedures required" for approval of a fluoridation installation by the State. In evaluating the adequacy of the water fluoridation control program of the Division of Sanitary Engineering, twenty-four public water supply systems in the State reported to be adding fluorides were surveyed to determine the adequacy of the installations operating under the approval of the Department of Public Health.

A total of 119 community water supply systems, serving 209 of the 445 communities supplied by public water systems in the State, were reported adding fluorides when the evaluation survey was initiated. Twenty-four of the 119 systems were selected for rating as being representative of the fluoridation installations in operation. The selection of the twenty-four supplies was based on the following criteria: georgraphical location, source of water supply (ground or surface), population served, fluoride compound used in fluoridation, type of feeder, and fluoride analysis method and test instrument used. Three supplies were chosen in each of the eight Health Planning Districts of the State to give representative geogrphical coverage. Selection based on the other criteria noted was according to the same approximate percentages these criteria existed for all the 119 water supply systems fluoridating (i.e., if 11% of the 119 installations in the State were feeding hydrofluosilicic acid as a source of fluoride ion, 11% of the twenty-four or three water supply systems chosen for the study were feeding hydrofluosilicic acid). Figure 1, Fluoridated Water Supply Systems Selected for Study, locates the twenty-four installations evaluated and Table I summarizes pertinent information on each facility.

A field inspection was conducted at each of the twenty-four installations selected, a survey questionnaire form was completed at the facility1), and water samples for fluoride analysis were collected to support the conclusions and recommendations in the report.

Summary of Findings

Data collected on the water supply systems fluoridating in the State of Tennessee indicated only twelve of the twenty-four installations selected for study, evidenced a fluoride content in the distribution system within the established 0.8 - 1.2 mg/l range recommended by the Department of Public Health. Two of the twenty-four installations visited, Elizabethton and Sewanee, had not been feeding fluorides for 51 and 294 days respectively prior to the visit and were not rated. Of the remaining ten installations that were not fluoridating within the established range, nine were underfeeding. TableII, Analysis of Samples From Selected Fluoridated Water Supply Systems, tabulates the fluoride analysis results of the water samples collected at each installation surveyed.2)

The actual level of fluoride in the distribution system is the single most important factor in evaluating the adequacy of a community water

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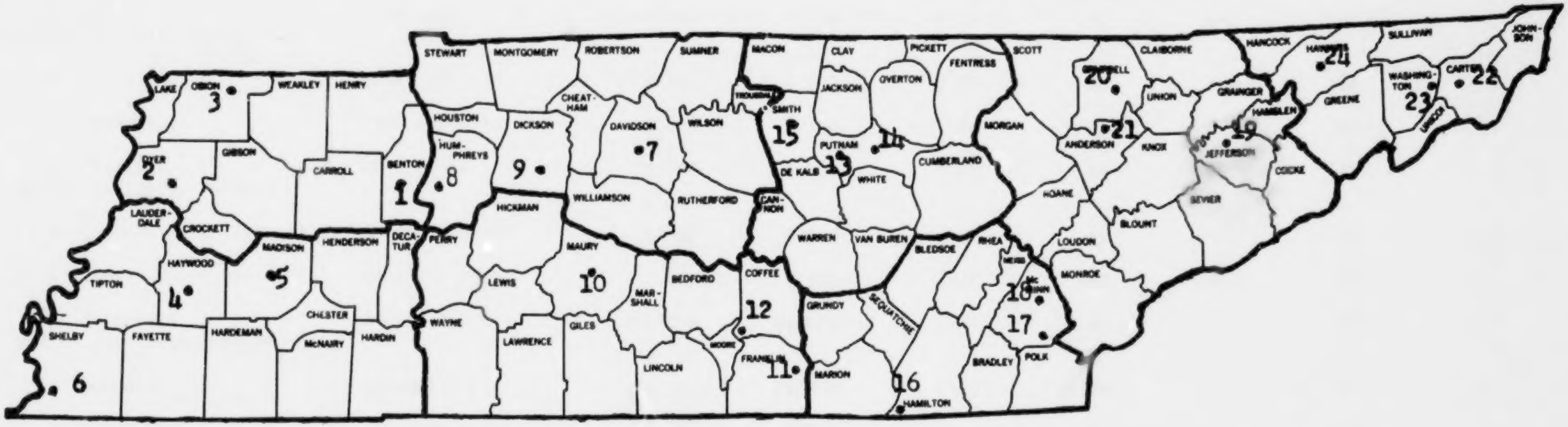
1) A copy of the Tennessee Fluoridation Questionnaire used is appended.

2) Fluoride samples were analyzed using the Electrode Method by Dr. Ervin Bellack, Chemist, Bureau of Water Hygiene, U. S. Public Health Service.

Tennessee Water Supply Program Evaluation
Figure 1
FLUORIDATED WATER SUPPLY SYSTEMS SELECTED FOR STUDY


LAKE
OBION
3
WEAKLEY
HENRY
DYER
2
GIBSON
CARROLL
BENTON
1
LAUDERDALE
CROCKETT
HAYWOOD
4
TIPTON
MADISON
5
HENDERSON
DECATUR
CHESTER
SHELBY
6
FAYETTE
HARDEMAN
McNAIRY
HARDIN
STEWART
MONTGOMERY
ROBERTSON
SUMNER
HOUSTON
HUMPHREYS
8
DICKSON
9
CHEATHAM
DAVIDSON
7
WILSON
TROUSDALE
SMITH
15
PERRY
HICKMAN
WILLIAMSON
RUTHERFORD
CANNON
WAYNE
LEWIS
MAURY
10
MARSHALL
BEDFORD
COFFEE
12
LAWRENCE
GILES
LINCOLN
MOORE
FRANKLIN
11
MACON
CLAY
JACKSON
PICKETT
OVERTON
FENTRESS
PUTNAM
13
14
DE KALB
WHITE
CUMBERLAND
WARREN
VAN BUREN
BLEDSOE
GRUNDY
SEQUATCHIE
MARION
16
HAMILTON
SCOTT
MORGAN
ROANE
RHEA
MEIGS
McMINN
18
17
BRADLEY
POLK
CAMPBELL
20
ANDERSON
21
CLAIBORNE
UNION
KNOX
LOUDON
MONROE
BLOUNT
GRAINGER
HAMBLEN
19
JEFFERSON
SEVIER
COCKE
HANCOCK
HAWKINS
24
GREENE
SULLIVAN
WASHINGTON
23
CARTER
22
UNICOI
JOHNSON

Region I: Northwest
1 - Camden
2 - Dyersburg
3 - Union City

Region II: Southwest
4 - Brownsville
5 - Jackson
6 - Memphis

Region III: Mid-Cumberland
7 - Nashville
8 - New Johnsonville
9 - Turnbull U.D. (Burns)

Region IV: South Central
10 - Columbia
11 - Sewanee
12 - Tullahoma

Region V: Upper Cumberland
13 - Baxter
14 - Cookeville
15 - Smith U.D. (Carthage)

Region VI: Southeast
16 - Chattanooga
17 - Etowah
18 - Niota

Region VII: East Tennessee
19 - Jefferson City
20 - La Follette
21 - Lake City

Region VIII: First Tennessee
22 - Elizabethton
23 - Johnson City
24 - Rogersville

TENNESSEE WATER SUPPLY PROGRAM EVALUATION
TABLE I
FLUORIDATED WATER SUPPLY SYSTEMS SELECTED FOR STUDY

WATER SUPPLY SYSTEM	SOURCE OF SUPPLY	POPULATION SERVED	AVG. FLOW (MGD)	DATE STARTED	FLUORIDE COMPOUND	TYPE OF FEEDER	TEST METHOD	TEST EQUIPMENT
Region I: Northwest								
1. Camden	Kentucky Lake	4,000	0.425	8/65	VS	V-1	S	T-1
2. Dyersburg	3-Wells	20,000	3.000	3/57	VS	V-2	S	T-2
3. Union City	4-Wells	10,000	2.000	2/56	VS	V-1	SS	T-3
Region II: Southwest								
4. Brownsville	4-Wells	7,000	0.750	6/51	VS	V-1	SS	T-4
5. Jackson	11-Wells	45,000	5.500	11/62	VS	V-1	SS	T-3
6. Memphis	149-Wells	620,000	82.600	2/70	VA	P-1	E	T-5
Region III: Mid-Cumberland								
7. Nashville	Cumberland River	425,000	60.000	2/53	VS	G-1	SS	T-3
8. New Johnsonville	Kentucky Lake	950	0.100	7/66	VS	V-1	SS	T-3
9. Turnbull U.D. (Burns)	Turnbull Creek	9,500	0.800	1/67	VS	V-3	SS	T-3
Region IV: South Central								
10. Columbia	Duck River	30,000	4.675	6/60	VS	V-2	SS	T-3
11. Sewanee(1)	Lake O'Donnell	2,960	0.380	7/59	VT	V-1	SS	T-3
12. Tullahoma	Short Springs	18,000	1.500	6/60	VS	V-4	SS	T-3
Region V: Upper Cumberland								
13. Baxter	2-Springs	1,200	0.130	6/54	VS	P-2	S	T-1
14. Cookeville	Falling Water River	18,300	2.580	12/52	VS	V-1	SS	T-3
15. Smith U.D. (Carthage)	Caney Fork River	2,000	0.380	3/69	VS	V-1	SS	T-3

WATER SUPPLY SYSTEM	SOURCE OF SUPPLY	POPULATION SERVED	AVG. FLOW (MGD)	DATE STARTED	FLUORIDE COMPOUND	TYPE OF FEEDER	TEST METHOD	TEST EQUIPMENT
Region VI: Southeast								
16. Chattanooga	Tennessee River	250,000	46.560	9/52	VA	P-2	S	T-6
17. Etowah	Hiwassee River	7,000	1.050	6/66	VS	V-5	S	T-1
18. Niota	Malone Spring	1,800	0.190	3/64	VT	P-3	SS	T-3
Region VII: East Tennessee								
19. Jefferson City	Mossy Spring	7,500	1.100	12/66	VS	V-1	SS	T-3
20. La Follette	Ollis Spring	10,000	0.500	8/57	VS	V-1	SS	T-3
21. Lake City	1-Spring	2,500	0.110	8/67	VS	P-4	SS	T-3
Region VIII: First Tennessee								
22. Elizabethton (2)	Hampton Springs	17,400	2.500	6/66	VS	V-1	SS	T-3
23. Johnson City (3)		50,000	6.500	8/61				
Watauga System	Watauga River				VA	P-1	SS	T-3
Unicoi System	2-Springs				VS	V-1	S	T-7
24. Rogersville	Big Creek	5,700	0.475	1/66	VS	V-1	S	T-1

Fluoride Compound:
VA - Hydrofluosilic Acid
VS - Sodium Silicofluoride
VT - Sodium Fluoride (Powder)

Test Method:
S - Spadns
SS - Scott-Sanchis
E - Electrode

(1) Fluoridation discontinued 10/15/69-shortage of chemicals reported
(2) Fluoridation discontinued 8/3/70-feeder repairs required
(3) Fluoridation discontinued in Unicoi System - chlorine accident

Type of Feeder:
V-1 Volumetric - W & T A-378 Roll Type
V-2 Volumetric - W & T A-690 Screw Type
V-3 Volumetric - BIF 23-02 Rotating Disk
V-4 Volumetric - BIF 50-A Rotating Disk
V-5 Volumetric - BIF 25-01 Helix
G-1 Gravimetric - BIF 31-02 Loss-in-weight
P-1 Diaphragm Pump - BIF 1210 Chem-O-Feeder
P-2 Diaphragm Pump - W & T A-747 Metering Pump
P-3 Diaphragm Pump - W & T A-745 Metering Pump
P-4 Plunger Pump - W & T 222 Rocker Arm Pump

Test Equipment:
T-1 Photometer - Hellige Aqua Analyzer Model 950A
T-2 Photometer - Hach DR-A198
T-3 Color Comparator - Hellige Aqua Testor #611-75 Disc
T-4 Color Comparator - Taylor Water Analyzer, Slide
T-5 Expanded Scale pH Meter - Fisher Model 310 Accumet pH Meter

T-6 Spectrophotometer - Bausch & Lomb Spectronic 20
T-7 Automatic Analyzer - Hach CR-2024

TENNESSEE WATER SUPPLY PROGRAM EVALUATION
TABLE II
ANALYSIS OF SAMPLES FROM SELECTED FLUORIDATED WATER SUPPLY SYSTEMS

(Fluoride-Mg/l)

	WATER SUPPLY SYSTEM	DATE OF SAMPLE	RAW WATER	FINISHED WATER (OPERATOR)	FINISHED WATER (PHS)	DISTRIBUTION SYSTEM	
I.	Camden	7/23	0.15	1.0	0.94	0.90	0.93
	Dyersburg	9/15	0.15	1.0	0.70	0.71	0.70
	Union City	9/16	0.13	1.2	1.06	1.20	1.25
II.	Brownsville	9/17	<0.1	1.0	1.10	1.12	1.13
	Jackson	7/22	0.08	0.8	0.51	0.48	0.51
	Memphis - (1)					0.80	0.35
	Allen	9/14	0.12	1.0	0.94		
	Lichterman	9/14	0.07	0.9	0.85		
	McCord	9/14	0.11	0.8	0.79		
	Parkway	9/14	0.10	0.08	0.08		
	Sheahan	9/15	0.06	0.9	0.78		
III.	Nashville	7/21	0.11	1.04	0.96	1.10	1.05
	New Johnsonville	9/16	0.17	1.2	0.78	0.80	0.87
	Turnbull U.D. (Burns)	7/24	0.12	0.9	1.01	1.02	0.97
IV.	Columbia	7/21	0.17	1.0	1.17	1.19	1.18
	Sewanee (2)	8/6	0.04	-	0.03	-	-
	Tullahoma	8/7	0.05	1.1	0.86	0.90	0.91
V.	Baxter (3)	8/4	0.11	-	0.49	0.42	0.49
	Cookeville	8/4	0.27	1.0	1.06	1.03	1.10
	Smith U.D. (Carthage)	8/3	0.17	1.0	1.30	0.85	1.04
VI.	Chattanooga	8/6	0.11	0.64	0.59	0.25	0.42
	Etowah	8/5	0.02	1.06	0.54	0.62	0.62
	Niota	8/5	0.15	0.9	1.01	0.97	0.68

(Fluoride-Mg/l)

WATER SUPPLY SYSTEM	DATE OF SAMPLE	RAW WATER	FINISHED WATER		DISTRIBUTION SYSTEM	
			(OPERATOR)	(PHS)		
VII. Jefferson City	9/21	0.15	1.2	1.00	1.00	1.02
La Follette	9/22	0.14	0.9	1.02	1.05	1.05
Lake City	9/22	0.36	1.0	0.46	0.46	0.45
VIII. Elizabethton(4)	9/24	0.11	-	-	0.09	0.09
Johnson City(5)	9/24	0.14	0.9	1.05	1.18	1.13
Rogersville	9/23	0.16	1.0	0.80	0.30	0.41

(1) Fluorides are added at five treatment plants. Parkway Plant under major construction improvements during survey and not operating.

(2) Fluoridation discontinued 10/15/69 - shortage of chemicals reported.

(3) No fluoride analysis conducted by operator. Samples, 4/yr, sent to state.

(4) Fluoridation discontinued 8/3/70 - feeder repairs required.

(5) Watauga System. Fluoridation discontinued in Unicol System - chlorine accident.

fluoridation effort and hence the State Water Fluoridation Control Program responsible for approval of the installation. However, because two distribution samples on one particular day may not give a true picture of day-to-day operating conditions of the facility, the following questions were investigated:

I. Analytical Control of the Fluoride Level-

A. Were the fluoride analysis conducted at the water plant accurate within ± 0.1 mg/l of the value determined by the Public Health Service?

B. Were finished water samples analyzed daily or more frequent for fluoride content?

C. Were raw water samples analyzed regularly for fluoride content?

D. Were laboratory equipment and facilities at the water plant adequate to conduct a fluoride analysis?

E. Was laboratory equipment clean and being given reasonable care?; and,

F. Were complete records kept of the fluoridation operation?

Analytical control of the fluoride level by the plant operator or chemist varied considerably. Only 48% of the fluoride analysis results reported at the water plant were within ± 0.1 mg/l of the sample analyzed by the Public Health Service and, while 82% of the supplies were conducting daily finished water fluoride sample analysis, only 50% were analyzing the raw water regularly for fluoride content. Only one community was taking water samples from the distribution system for analysis. Adequate laboratory equipment for fluoride analysis was available at 95% of the installations visited but care of the equipment was a problem at 24% of the installations. Records of the fluoridation operation were acceptable at only 59% of the water supply systems surveyed.

II. Fluoride Feed Equipment and Facilities-

A. Were the fluoride feed equipment and facilities adequate to control the fluoride level in the finished water to the desired level?

B. Was positive protection provided against overfeeding, was equipment location and point of fluoride application at the best practical site and was the feed equipment site uncluttered?

C. Was the fluoride feed installation operated continuously for the past twelve months without an interruption of more than one day?; and,

D. Were the fluoride feed equipment and facilities maintained satisfactorily?

Fluoride feed equipment and facilities deficiencies were found in 23% of the installations visited and only 50% of the feeding arrangements were rated acceptable, i.e. protected against overfeeding, preferred point of feed application and good housekeeping in the feeder area. Nineteen percent of the installations reported one or more interruptions in fluoridation of one or more days duration in the past twelve months and maintenance was found satisfactory at only 36% of the installations surveyed.

III. Fluoride Compound - Storage and Handling

A. Was the fluoride chemical compound stored in a safe, protected and orderly manner?

B. Were safety equipment available and safe procedures followed in handling the fluoride compound, and were dry compounds tinted as required?; and,

C. Were fluoride compound shipping containers disposed of satisfactory or re-used only for fluoride storage?

Forty-one percent of the installations visited did not have acceptable arrangements for storing the fluoride compound used. Fifty-five percent of the facilities surveyed did not have or were not using safety equipment in handling the fluoride compounds and/or were not using tinted dry compounds as required by the State. Twenty-one percent of the installations using dry compounds as a source of fluoride ion were permitting re-use of the shipping containers.

IV. Operator Training and Interest

A. Was the treatment plant operator well trained to operate the fluoride feed equipment and facilities?

B. Was the individual conducting the fluoride analysis knowledgeable of his test equipment and standard procedures for analysis?

C. Was the water plant official interviewed in favor of fluoridation and was he interested in adding fluorides to his water system?

A trained operator with a genuine interest in feeding fluorides is essential to the satisfactory operation of a fluoridation installation. One of the twenty-two installations rated was under the control of an operator not familiar with the fluoride feed equipment and 18% of the operators interviewed were not completely familiar with the test equipment and procedures used in conducting a fluoride analysis. Twenty-seven percent of the water plant officials interviewed did not favor feeding fluorides to public water supply systems.

V. Surveillance

A. Were check samples for fluoride analysis submitted to the State on a regular basis, four times per year?; and

B. Had the water fluoridation installation surveyed been inspected by the State in the past twelve months?

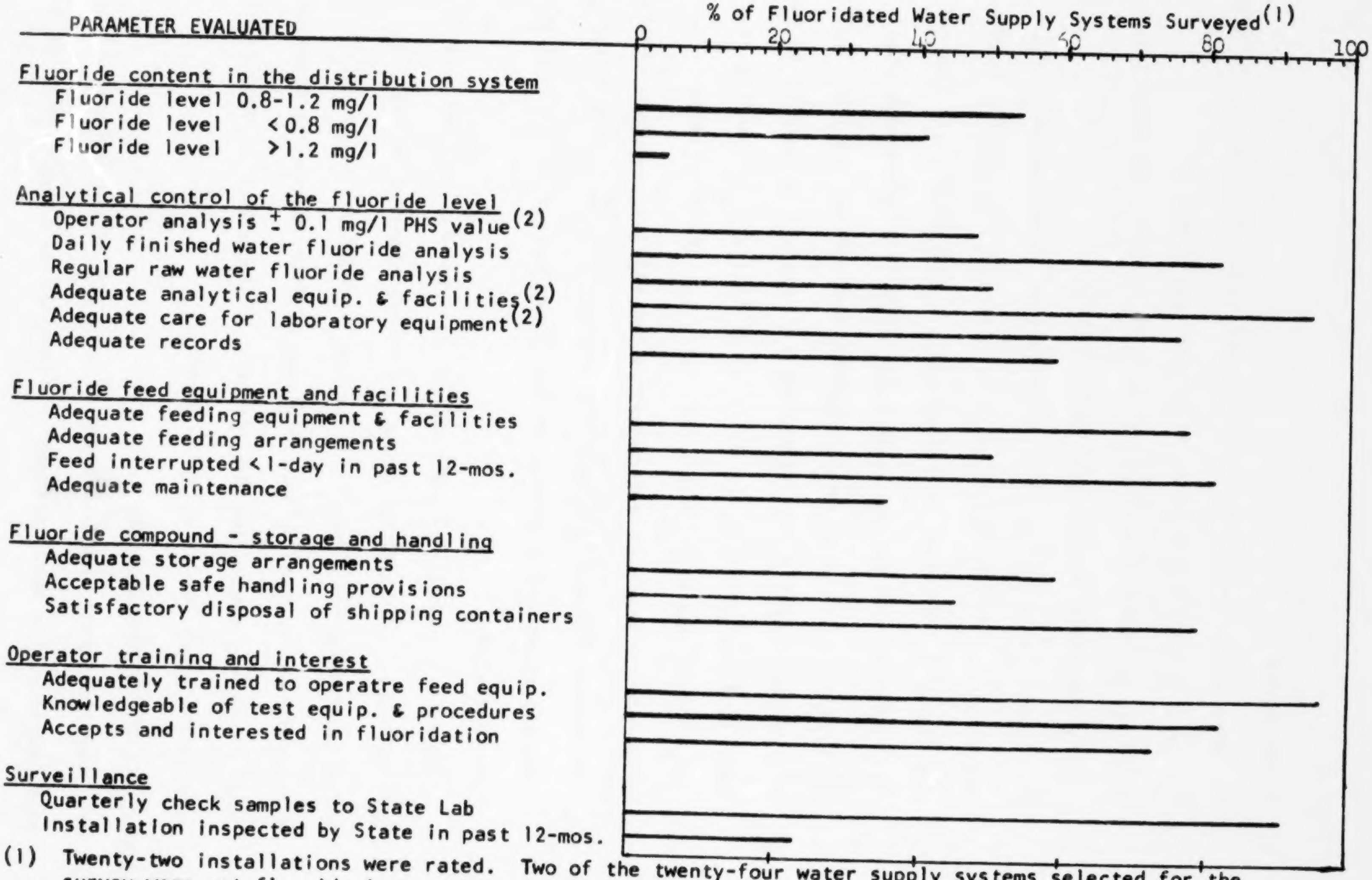
Surveillance of the water fluoridation installations by the Department of Public Health must be conducted frequently, to assure the facility is operating satisfactory. Quarterly check samples for fluoride analysis by the State Laboratory were being submitted regularly by 91% of the water systems surveyed as required; however, 77% of the installations rated had not received an inspection visit by a representative of the Division of Sanitary Engineering in the past twelve months. Inspection visits to the installations fluoridating averaged approximately one visit in eighteen months. To improve the general operating conditions observed, more frequent check samples and a minimum of two inspected visits per year must be initiated.

Figure 2, Operating Conditions at Selected Fluoridated Water Supply Systems, summarizes the operating conditions observed at the installations inspected during the time of the survey. Conditions varied widely at each installation and Table III, Adequacy of Fluoridation at Selected Water Supply Systems, summarizes the adequacy of the operating conditions observed at each installation surveyed.

Conclusions and Recommendations

1. 119 community water supply systems serving 209 of the 445 communities supplied by public water systems in Tennessee were reported to be

TENNESSEE WATER SUPPLY PROGRAM EVALUATION
FIGURE 2
OPERATING CONDITIONS AT SELECTED FLUORIDATED WATER SUPPLY SYSTEMS



(1) Twenty-two installations were rated. Two of the twenty-four water supply systems selected for the survey were not fluoridating at the time of the field visit.

(2) Twenty-one installations were rated. One of the water systems fluoridating was not conducting fluoride analysis regularly.

TENNESSEE WATER SUPPLY PROGRAM EVALUATION
TABLE III
ADEQUACY OF FLUORIDATION AT SELECTED WATER SUPPLY SYSTEMS

PARAMETER EVALUATED	Camden	Dyersburg	Union City	Brownsville	Jackson	Memphis	Nashville	New Johnsonville	Turnbull U.D.	Columbia	Sewanee(1)	Tullahoma	Baxter	Cookeville	Smith U.D.	Chattanooga	Etowah	Niota	Jefferson City	La Follette	Lake City	Elizabethton(2)	Johnson City(3)	Rogersville
Fluoride content in the distribution system																								
Fluoride level 0.8-1.2 mg/1	OK			OK			OK	OK	OK	OK		OK		OK	OK				OK	OK			OK	
Fluoride level 0.8 mg/1		X			X	X							X			X	X	X			X			X
Fluoride level 1.2 mg/1			X																					
Analytical control of the fluoride level																								
Operator analysis ± 0.1 mg/1 PHS value	OK	X	OK	OK	X	OK	OK	X	OK	X		X	(4)	OK	X	OK	X	OK	X	OK	X		X	X
Daily finished water fluoride analysis	X	OK	OK	X	OK	OK	OK	OK	OK	OK		OK	X	OK	OK	OK	OK	OK	OK	OK	X		OK	OK
Regular raw water fluoride analysis	X	OK	X	X	OK	X	OK	OK	OK	X		OK	X	X	X	OK	OK	X	OK	X	OK		OK	X
Adequate analytical equip. and facilities	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK		OK	N/A	OK	OK	OK	OK	X	OK	OK	OK		OK	OK
Adequate care for laboratory equipment	OK	OK	OK	OK	X	OK	OK	X	OK	OK		OK	N/A	X	OK	OK	OK	X	OK	OK	X		OK	OK
Adequate records	X	OK	X	X	OK	OK	OK	OK	OK	X		OK	X	OK	OK	OK	OK	X	OK	X	X		OK	X
Fluoride feed equipment and facilities																								
Adequate feeding euipment & facilities	OK	X	X	OK	OK	OK	OK	X	OK	OK		OK	OK	OK	OK	OK	OK	X	OK	OK	X		OK	OK
Adequate feeding arrangements	X	X	X	OK	X	OK	OK	OK	X	OK		OK	OK	X	OK	X	OK	X	X	X	X		OK	OK
Feed interrupted 1-day in past 12-mos.	OK	OK	OK	OK	OK	(5)	OK	OK	OK	OK		OK	X	OK	X	X	OK	X	OK	OK	OK		OK	OK
Adequate maintenance	OK	X	X	X	X	OK	X	OK	X	OK		OK	X	X	OK	X	OK	X	X	X	OK		X	X
Fluoride compound - storage and handling																								
Adequate storage arrangements	X	OK	X	OK	X	OK	X	OK	X	X		OK	X	OK	OK	OK	OK	X	OK	X	OK		OK	OK
Acceptable safe handling provisions	OK	OK	X	X	OK	OK	OK	OK	X	X		OK	X	X	X	OK	OK	X	X	X	X		OK	X
Satisfactory disposal of shipping containers	X	OK	OK	OK	OK	N/A	OK	OK	X	OK		OK	OK	X	OK	N/A	OK	X	OK	OK	OK		N/A	OK
Operator Training and interest																								
Adequately trained to operate feed equipment	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK		OK	X	OK	OK	OK	OK	OK	OK	OK	OK		OK	OK
Knowledgeable of test equip. & procedures	X	OK	OK	OK	OK	OK	OK	OK	OK	OK		OK	X	OK	OK	OK	OK	X	OK	OK	X		OK	OK
Accepts and interested in fluoridation	OK	OK	OK	OK	OK	OK	OK	X	X	OK		OK	X	OK	OK	X	OK	X	OK	OK	OK		OK	X

	Camden	Dyersburg	Union City	Brownsville	Jackson	Memphis	Nashville	New Johnsonville	Turnbull U.D.	Columbia	Sewanee(1)	Tullahoma	Baxter	Cookeville	Smith U.D.	Chattanooga	Etowah	Niota	Jefferson City	La Follette	Lake City	Elizabethton(2)	Johnson City(3)	Rogersville
Surveillance																								
Quarterly check samples to State Lab	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK		OK	OK	OK	OK	OK	OK	X	OK	OK	OK		X	OK
Installation inspected by State in past 12-months	X	X	X	X	OK	OK	OK	X	X	OK		X	X	X	X	X	X	X	X	X	X		OK	X

(1) Fluoridation discontinued 10/15/69 - shortage of chemicals reported
(2) Fluoridation discontinued 8/3/70 - feeder repairs required
(3) Watauga System. Fluoridation discontinued in Unicoi System
(4) No fluoride analysis conducted by operator
(5) Fluoridation initiated February 1970
X Deficiency

fluoridating. Since no dentally significant concentrations of natural fluorides are known in any of the public water supplies in the State, only 47% of the community water supply systems are attempting to supply fluoridated water.

Recommendation:

The Tennessee Department of Public Health should more actively promote fluoridation in Tennessee and strengthen their financial assistance program to institute controlled fluoridation throughout the State. The adoption of a State Law requiring the fluoridation of all public water supplies in Tennessee as now exists in several other states should be pursued.

2. Fifty-four percent of the water supply system reported fluoridating contained fluoride levels within the 0.8 - 1.2 mg/l range recommended by the Department of Public Health. Only 48% of the fluoride analysis results reported were within ± 0.1 mg/l of the sample analysis value reported by the Public Health Service.

Recommendation:

The Department of Public Health, Division of Sanitary Engineering should concentrate their effort in water fluoridation to assist the water plant operator at fluoridation installations to control the fluoride level in the distribution system within the recommended range, and conduct fluoride analysis within ± 0.1 mg/l of the State check sample value. Mandatory daily distribution sample fluoride analysis, regular raw water sampling for fluoride, adequate laboratory equipment and care of equipment and complete records should be required at all installations.

3. Fluoride feed equipment and facilities to control the distribution system fluoride levels to between 0.8 and 1.2 mg/l and satisfactory arrangements

for feeding fluorides did not exist at all the installations surveyed. Maintenance conditions were satisfactory at only 36% of the facilities surveyed.

Recommendation:

The Department of Public Health Division of Sanitary Engineering should provide design assistance to all communities proposing to install fluoridation facilities, review all proposed installations before the operation is approved and assist the operator as needed during the "start-up" period of fluoridation. Fluoride saturators should be considered at the smaller systems in preference to batch-type feed systems. Four visits to a new installation should be required during the first year to assure satisfactory operation of the facility. A preventative maintenance program should be established by the Division of Sanitary Engineering for each system and closely followed for the installation to receive continued approval.

4. Storage arrangements and safety precautions for handling the fluoride compounds used were judged inadequate at 41% and 55% of the installations surveyed respectively.

Recommendation:

The Department of Public Health Division of Sanitary Engineering should develop and adopt an acceptable arrangement for storing fluoride compounds and a safety procedure for handling the compounds. Installations not complying with the requirements should not be approved. The Division of Sanitary Engineering should require that all fluoride compounds used meet AWWA Specifications.

5. A trained water plant operator with a genuine interest in feeding fluorides is essential to the satisfactory operation of a fluoridation installation. Training deficiencies were noted in the water plant operators knowledge of his fluoride feed equipment and particularly his acquaintance with the test equipment and procedures used in conducting fluoride analysis.

   Recommendation:

   The Department of Public Health Division of Sanitary Engineering should expand their short school training program to include a training course in fluoride determinations in water and equipment operation for the operators of the fluoridated water supply systems. Satisfactory completion of the course should be a mandatory requirement of the plant operator for approval of his installation to feed fluorides.

6. Frequent check samples of fluoride levels in the distribution system and regular inspection visits to the water fluoridation installation by a representative of the Division of Sanitary Engineering must be conducted to assure the facility is operating satisfactory. Inspection visits to the installations fluoridating averaged one visit every eighteen months.

   Recommendation:

   The Department of Public Health, Division of Sanitary Engineering should require a minimum of one check sample per month from each installation fluoridating and should conduct two field inspection per year of the facility. A field staff of approximately double the personnel now conducting water supply program evaluations is estimated to be needed.

TENNESSEE FLUORIDATION SURVEY

Water System:

Population Served: **Average Flow:**

Date Fluoridation Started:

Source of Supply:

Treatment:

Natural Fluoride:

Fluoridation Equipment -

Manufacturer:

Type:

Model:

Location:

Point of application:

Condition of equipment:

Operational problems:

Overfeeding safeguards:

Remarks:

Fluoride Compound -

Chemical: Cost:

Source:

Form of shipment:

Storage facilities:

Quantity used:

Safety provisions:

Remarks:

Control of Fluoridation -

Frequency of sampling:
Raw water: Finished water:

Sampling point:

Test method:

Test instrument:

Records:

Interruptions:

Remarks:

Operator Qualifications -

Experience:

Training:

Interest:

Remarks:

Surveillance -

Check samples:

Last visit by State:

Availability of technical assistance:

Remarks:

Comments -

APPENDIX E

REGULATIONS - PUBLIC WATER SUPPLIES

Tennessee Department of Public Health
Division of Sanitary Engineering

Under Sections 2 and 3, Chapter 52, Public Acts of 1945, authorizing the Tennessee Department of Public Health to exercise supervision over the construction, operation, and maintenance of public water supplies and public sewerage systems, the following regulations have been officially adopted by the Public Health Council on this the 17th day of May, 1945. These regulations will have the full force of law from the date of adoption, and all previously promulgated regulations of the Department relating to public water supplies which are in conflict with these regulations are hereby repealed.

The Division of Sanitary Engineering will be responsible for the supervision of public water supplies and the Director of this Division will be the authorized agent of the Commissioner.

REGULATION W-1. TERMS USED

Definition of terms as set forth in Section 1, Chapter 52, Public Acts of 1945, shall be used in the interpretation of these regulations.

REGULATION W-2. SUPERVISION OVER CONSTRUCTION OF PUBLIC WATER SUPPLIES

(a) Preliminary Plans. Whenever any new construction or any major change of an existing system is contemplated, a statement concerning the proposed construction or change together with preliminary plans, reports, and cost estimates shall be submitted to the Tennessee Department of Health. These data will be reviewed, and, if sufficient to indicate the scope and intent of the project, the Department will outline general requirements for its final approval.

(b) Water Samples. Whenever any new construction or change of an existing system involves a new source of supply, such samples shall be submitted for chemical, bacteriological or other examinations as the Department may direct. The quality of the water must be approved by the Department before such water is made available for drinking or other domestic uses.

(c) Complete Plans. Before work is commenced on any new construction or major change of an existing system, complete plans and specifications and cost estimates, together with such additional data as may be required to determine the suitability of the works, shall be submitted to the Tennessee Department of Public Health, and no part of the work shall be commenced until the Department has given its written approval. All such plans shall be submitted at least two weeks prior to the date upon which action of the Department is desired.

(d) Revision of Plans. In case it is necessary or desirable to make any material change in the approved plans and specifications, revised plans and specifications, together with a statement of the reasons for the changes, shall be submitted to the Tennessee Department of Public Health for review and no part of the work affected by the change or changes shall be commenced until the Department has given its written approval.

(e) Work in Conformity with Plans and Specifications. All work on new construction or changes of existing systems shall be done in conformity with approved plans and specifications. The Department may require reports and make investigations during and following the completion of any construction to determine whether or not work is being done or has been done in conformity with approved plans.

(f) Records of Existing Works. Whenever there is a question concerning the suitability of existing structures or other parts of the system to insure the safety of the water supply, the Department may require the submission of plans or other data necessary to ascertain the details of such works in relation to their possible direct or indirect effect on the sanitary quality of the public water supply.

REGULATION W-3. SUPERVISION OVER OPERATION OF PUBLIC WATER SUPPLIES

(a) Records and Reports. Daily records of operation of water works systems shall be kept, and these data shall be submitted to the Tennessee Department of Public Health on forms supplied by the Department. Reports may be required either weekly, monthly, or as deemed necessary to ascertain the continuous production of a safe water.

(b) Water Samples. Samples of water shall be submitted to the Tennessee Department of Public Health when and in such manner as the Department may direct. Samples for bacteriological examinations shall be collected in regulation bottles furnished by the Department and mailed or brought to the Central Laboratory or one of the branch laboratories as designated. Samples may be requested for chemical and physical examination at any time and such samples shall be collected and mailed or otherwise delivered to the Department in accordance with instructions.

(c) Supervision and Operation. The supervision, operation, and maintenance shall be of such character as in the opinion of the Tennessee Department of Public Health will produce a satisfactory water at all times as judged by the current standards of the Department. Evidence of competence may be required if and when deemed necessary by the Commissioner to insure proper operation and maintenance of any public water supply.

REGULATION W-4. CROSS-CONNECTIONS, AUXILIARY INTAKES, BY-PASSES, AND INTER-CONNECTIONS.

(a) Cross-Connection. No connection between the distribution system of any public water supply and that of any other water supply shall be permitted unless the quality of such other water supply, the arrangement for connecting, and the operation of the two supplies have been approved in writing by the Tennessee Department of Public Health. Also, both supplies must be continuously under the supervision of the Department and the responsible official or officials of the Public Water supply. Records of such approved connections must be submitted to the Department as often and in such detail as directed. Two public water supplies may be cross-connected provided the construction, operation, and maintenance of both are satisfactory to the Tennessee Department of Health and the arrangement and responsibility for such connection is jointly agreed upon and submitted in writing to the Department for approval.

(b) Auxiliary Intakes. No auxiliary intake for a public water supply shall be permitted unless the source and use of such auxiliary supply and the location and arrangement of the intake have been approved by the Tennessee Department of Public Health. Plans for an auxiliary intake must be submitted to the Department in the same manner as for a new supply or a new source.

(c) By-Pass. No by-pass shall be permitted at any water treatment plant of a public water supply unless such by-pass is approved by the Tennessee Department of Public Health. Plans and other data necessary for the Department to assure itself that htere is no direct or indirect danger to the water quality must be submitted along with any request for approval of a by-pass.

(d) Inter-connections. No system of piping or other arrangement whereby a potable water supply is connected directly with a sewer, drain, conduit or other device which does or may carry sewage or other waste which would be capable of imparting contamination to the public water supply shall be permitted. If such a connection is suspected, the Department may require the submission of such data as necessary to positively ascertain that there is no chance of sewage or other waste finding its way into any part of the public water supply system.

(e) Non-Potable Water. Whenever a public water supply is available on any premises having a non-potable supply which is used for industrial, fire protection, or other purposes, such non-potable supply shall be distributed through an independent piping system having no cross-connection with the potable supply. Such non-potable supply shall be labeled in such manner as may be directed and shall not be available for drinking or other personal or domestic uses. The owner or operator of such non-potable supply shall file a statement with the official responsible for the public water supply stating that there are no cross-connections with the non-potable supply and that none will be permitted.

REGULATION W-5. INVESTIGATIONS, REPORTS, RECOMMENDATIONS, STANDARDS AND ORDERS.

(a) Investigations. The Commissioner through the Division of Sanitary Engineering shall arrange for such investigations, either routine or special as in his judgment may be necessary to insure proper construction, operation and maintenance of public water supplies and to insure compliance with these regulations.

(b) Reports. Reports of investigations together with recommendations regarding improvements or other matters relating to any public water supply shall be prepared and forwarded to the official responsible for such system as often as deemed necessary by the Director of the Division.

(c) Standards. The Department shall prepare and disseminate such information concerning public water supplies as it may deem necessary or desirable to insure the production and distribution of safe water. It shall prepare, adopt or utilize such standards as necessary to properly interpret the sanitary quality of water being produced by any public water supply of Tennessee.

(d) Special Orders. Whenever it is the judgment of the Tennessee Department of Public Health, based upon investigation, that a public water supply is an actual or potential menace to public health, because of faulty design, inadequacy, improper supervision or inefficient operation, and that effective measures are not being carried out to correct these defects, the Department may issue an order for its correction, and such order or orders shall be complied with within the time limit specified in the order.
8/18/45

SPECIAL REGULATION – PUBLIC WATER SUPPLIES

Tennessee Department of Public Health
Division of Sanitary Engineering

Policy, Procedure and Requirements for Fluoridation of Public Water Supplies

Under Title 53, Chapter 20 Tennessee Code Annotated 53-2001-2016 authorizing the Tennessee Department of Public Health to exercise supervision over the construction, operation and maintenance of public water supplies and public sewerage systems, the following special regulations have been officially adopted by the Public Health Council on this the eighth day of April, 1963.

POLICY:

Inasmuch as a wealth of evidence has been gathered to show the dental benefits of controlled fluoridation of public water supplies, the Tennessee Department of Public Health encourages all cities, towns, and utility districts with an approved water supply to consider seriously the adoption of this very important preventive health measure.

Prior to approval, the Division of Sanitary Engineering will determine the adequacy of the equipment and proposed technical supervision, and engineers of the Division will advise local officials concerning details of the treatment and laboratory procedures required. Written approval of the Division is necessary before fluoridation equipment is installed, and an engineer from the Division must be present when the fluoride is first added to the water supply. The water supply must be Approved.

Procedure for Obtaining Approval:

1. The governing body will authorize, by passage of a suitable ordinance, the fluoridation of the water supply and instruct the responsible water department officials to prepare the necessary plans for obtaining approval of the State Health Department.

2. Detailed plans showing the method and point of application of fluoride and storage facilities for stock chemical will be forwarded to the Division of Sanitary Engineering for review and approval.

Special Regulation-Public Water Supplies

General Requirements for Approval:

1. Reliable feeding equipment with an accuracy within 5% will be provided to feed the desired dosage of fluoride. The rate of feed shall be such as to give a fluoride content of 0.8 to 1.2 ppm. in the treated water. The point of application will be selected so that the fluoride will be adequately mixed with the water before leaving the treatment plant.

2. If solution feed equipment is to be used, at least two solution tanks and accurate means for weighing the stock chemical and measuring the water for the solution are to be provided.

3. Special precautions must be taken to protect the operators from inhaling the fluoride. These precautions will vary with the type of installation but the minimum will be the provision of a toxic-dust respirator for each operator involved.

4. Laboratory facilities must be provided for the determination of the fluoride content of the water in accordance with the procedure outlined in the latest edition of *Standard Methods for the Examination of Water and Wastewater*.

5. Samples of raw water must be tested occasionally and plant effluent samples at least once daily and the results included on the regular operation report submitted to the State Health Department. Samples from the distribution system are to be sent to the Sanitary Engineering Division at weekly intervals until otherwise requested.

This regulation is in addition to Public Water Supply Regulations officially adopted by the Public Health Council May 17, 1945.

Approved both as to form and legality, April 23, 1963.

S/George F. McCanless
George F. McCanless, Attorney General

Adopted, April 19, 1963

S/R. H. Hutcheson
R. H. Hutcheson, Commissioner of Health

Filed, April 29, 1963

S/Joe C. Carr
Joe C. Carr, Secretary of State

SE-63-9
(completed)

PUBLIC WATER SUPPLY AND SEWER SYSTEM
Tennessee Code Annotated - Sections 53-2001 - 53-2008

SECTION.

53-2001. Definitions.
53-2002. Department exercising general supervision over construction of public water supplies and public sewerage systems.
53-2003. Operation and Maintenance supervised by Department.
53-2004. Cross-connections, auxiliary intakes, by-pass or interconnections to be approved--Drain lines or conduits carrying wastes not to enter water supply.
53-2005. Defects in water supply or sewerage ordered corrected when health menace.
53-2006. Review of order to correct--Procedure.
53-2007. Violation of provisions a misdemeanor--Penalty.
53-2008. Standards, orders, rules and regulations enforced by Department.

53-2001. Definitions--The terms used in §§ 53-2001--53-2008 are defined as follows:

"Waterworks system" - The source of supply and all structures and appurtenances used for the collection, treatment, storage and distribution of water delivered to the consumers. This shall not include waterworks systems for private residences or dwellings or waterworks systems for industrial purposes not intended for human consumption.

"Public water supply" - Any waterworks system as defined above, whether privately or publicly owned, where water is furnished to any community, collection or number of individuals for a fee or charge or any other waterworks system which on account of the people who are or may be affected by the quality of the water, is classified as a public water supply by the Tennessee Department of Public Health.

"Department" - The Tennessee Department of Public Health through its executive officer, the commissioner of public health, or his legally designated representative.

"Commissioner" - The Commissioner of the Tennessee Department of Public Health or his authorized agent.

"Potable water supply" - Any public or other water supply, the quality of which is approved by the Tennessee Department of Public Health for human consumption.

"Cross connection" - Any physical connection whereby a potable water supply system is connected with any other water supply system, whether public or private, either inside or outside of any building or buildings, in such manner that a flow of water into the potable water supply is possible, either through the manipulation of valves or because of ineffective check or back pressure valves.

"Auxiliary intake" - Any piping connection or other device whereby water may be secured from a source other than that normally used.

"By-pass" - Any system of piping or other arrangement whereby the water may be diverted around any part or portion of a water purification plant.

"Interconnection" - Any system of piping or other arrangement whereby a potable water supply is connected directly with a sewer, drain, conduit or other device which does or may carry sewage or other liquid or waste which would be capable of imparting contamination to the potable water supply.

"Public sewerage system" - The conduits, sewers, and all devices and appurtenances by means of which sewage is collected, pumped, treated or disposed of finally. This shall not include systems for private residences or dwellings.

"Sewage" - All water-carried human and household wastes from residences, buildings, institutions or industrial establishments, together with such ground, surface, or storm water as may be present.

"Person" - Any and all persons, natural or artificial, including any individual, firm or association and any municipal or private corporation organized or existing under the laws of this or any other state or country. (Acts 1945, ch. 52, § 1; C. Supp. 1950, § 5826. 1.)

53-2002. Department exercising general supervision over construction of public water supplies and public sewerage systems.--The department shall exercise general supervision over the construction of public water supplies and public sewerage systems throughout the state. Such general supervision shall include all of the features of construction of waterworks systems which do or may affect the sanitary quality of the water supply and all features of construction of sewerage systems which do or may affect the proper collection, treatment, or disposal of sewage. No new construction shall be done nor shall any change be made in any public water supply or public sewerage system until the plans for such new construction or change have been submitted to and approved by the department. In granting approval of such plans the department may specify such modifications, conditions, and regulations as may be required for the protection of the public health. The department is authorized to investigate the public water supplies and public sewerage systems throughout the state as often as is deemed necessary by the commissioner. The department is empowered to adopt and enforce rules and regulations governing the construction of public water supply and public sewerage systems, and may require the submission of samples of water or sewage for examination. Records of construction including plans and descriptions of existing works shall be made available to the department upon request. The person in charge of the public water supply or public sewerage system shall promptly comply with such request. (Acts 1945, ch. 52, § 2; C. Supp. 1950, § 5826.2)

53-2003. Operation and maintenance supervised by department.--The department shall exercise general supervision over the operation and maintenance of public water supply and public sewerage systems throughout the state. Such general supervision shall include all of the features of operation and maintenance which do or may affect the sanitary quality of the water supply and all of the features of operation and maintenance which do or may affect the proper treatment or disposal of sewage. For exercising such general supervision over the operation and maintenance of public water supply and public sewerage systems the department is authorized to investigate the public water supplies and public sewerage systems as often as is deemed necessary by the commissioner, and may adopt and enforce regulations governing the operation and maintenance of public water supply and public sewerage systems. Records of operation of public water supplies and of public sewerage systems shall be kept on blanks furnished by the department and this data shall be submitted to the department at such times and intervals as the department may direct. Samples of water or sewage shall be submitted to the department when and in such manner as the department may direct. When the department shall have required the submission of such records or reports of operation and samples of water or sewage the person in charge of the public water supply or public sewerage system shall promptly comply with such request. (Acts 1945, ch. 52, § 3; C. Supp. 1950, § 5826.3.)

53-2004. Cross connections, auxiliary intakes, by-pass or interconnections to be approved--drain lines or conduits carrying wastes not to enter water supply.--No person shall install, permit to be installed, or maintain any cross connection, auxiliary intake, by-pass, or interconnection, unless the source and quality of water from the auxiliary supply, the method of connection, and the use and operation of such cross connection, auxiliary intake, by-pass or interconnection has been approved by the department. The arrangement of sewer, soil, or other drain lines or conduits carrying sewage or other wastes in such manner that the sewage or waste may find its way into any part of the public water supply system is prohibited. (Acts 1945, ch. 52, § 4; C. Supp. 1950, § 5826.4.)

53-2005. Defects in water supply or sewerage system ordered corrected when health menace.--When the commissioner finds upon investigation that a public water supply or public sewerage system is an actual or potential menace to health because of improper location, quality of the source in case of public water supplies, inadequacy, faulty design, improper supervision, or inefficient operation, and that effective measures are not being carried out to correct these defects, the department may issue an order for their correction, and this order shall be complied with within the time limit specified in the order. Such notice shall be made by personal service or shall be sent by registered mail to the person responsible for the operation of the public water supply or public sewerage system. Investigations made in accordance with this section may be made at the initiative of the commissioner. (Acts 1945, ch. 52, § 5; C. Supp. 1950, § 5826.5.)

53-2006. Review of order to correct - procedure.--Any person against whom an order is issued may secure a review of the necessity for or reasonableness of any order of the department by filing with the department a sworn petition, setting forth the grounds and reasons for his objections and asking for a hearing of the matter involved. The department shall thereupon fix the time and place for such hearing and shall notify the petitioner thereof. At such hearing, the petitioner, and any other interested party, may appear, present witnesses, and submit evidence. Following such hearing the final order of determination of the department shall be conclusive, provided that such final order of determination may be reviewed in any court of competent jurisdiction upon petition therefor, filed within fifteen (15) days after such final order of determination has been issued. All such hearings shall be held in the county where the waterworks and/or sewerage system affected is located and if such system be located within any incorporated town than such hearing shall be held at a public place in such town, and the hearing shall be a public hearing.

The chancery court of the county wherein such system is located shall have exclusive original jurisdiction of all review proceedings instituted under the authority and provisions of §§ 53-2001-53-2008, whether such proceedings shall be instituted by the department of health, the waterworks system, the sewerage system or any company, corporation, municipality, or individual authorized to institute such review proceedings. (Acts 1945, ch. 52, § 6; C. Supp. 1950, § 5826.6.)

53-2007. Violation of provisions a misdemeanor - Penalty.--Any person violating any of the provisions of §§ 53-2001--53-2008, or failing, neglecting or refusing to comply with any order of the department lawfully issued, shall be guilty of a misdemeanor and, upon conviction, shall be liable to a fine of not less than ten dollars ($10.00) nor more than one hundred dollars ($100) for each violation within the discretion of the court, and each day of continued violation after conviction shall constitute a separate offense. (Acts 1945, ch. 52. § 7; C. Supp. 1950, § 5826.7.)

53-2008. Standards, orders, rules and regulations enforced by department.--The department may cause the enforcement of any standards, policies, general or special orders, rules or regulations issued by it to control public water supplies and public sewerage systems. Such suit or suits as may be necessary to effectually carry out the provisions of §§ 53-2001--53-2008 may be instituted, brought and prosecuted, in any court of competent jurisdiction. The district attorney-general in whose jurisdiction a violation of §§ 53-2001--53-2008 occurs or the attorney-general of the state--either or both as indicated--shall institute and prosecute such suits when necessity therefor has been shown by those herein clothed with power of investigation. (Acts 1945, ch. 52, § 8; C. Supp. 1950, § 5826.8.)

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WATER

FIELD INVESTIGATION REPORT — DIVISION OF SANITARY ENGINEERING

Tennessee Department of Public Health

Location ______________________ Date ______________________ 19____

PERSON CONTACTED	NAME	INTERVIEWED	REPORT	COPY
Mayor				
Recorder				
City Manager				
Superintendent				
Operator				
CHD				

Sample Record

ORGANISMS / 100 ML.												

Reports Submitted ____________ Certified Operator ____________

Remarks ____

____

____

____

____

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____

____

Recommendations ______________________________________

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____

Engineer ______________________

Report ______________________ Title ______________________

PUBLIC WATER SUPPLY RATING FORM—DIVISION OF SANITARY ENGINEERING

Tennessee Department of Public Health

Location ______________________________ Date ______________________

PHYSICAL EQUIPMENT

1. **Source of supply (10)**—Adequacy ( ) Standby ( ) Pollution hazards ( ) Spring supply intake ( ) Well supply protection ( ) Suction or gravity mains ( ) Raw water quality ( ) ______________ ( ) ( )
2. **Equipment, buildings & grounds (5)**—Low lift pumping equipment ( ) High lift pumping equipment ( ) All water works buildings & grounds ( ) Master meter ( ) Other equipment or structures ( ) ______________ ( ) ( )
3. **Treatment facilities (10)**—Aerators ( ) Chemical feeders ( ) Mixing devices ( ) Sedimentation units ( ) Filters & appurtenances ( ) Disinfection equipment ( ) ______________ ( ) ( )
4. **Laboratory facilities (5)**—Chemical & physical ( ) Bacteriological ( ) Space adequate for laboratory work ( ) ______________ ( ) ( )
5. **Potable water storage facilities (5)**—Ground level reservoir ( ) Elevated tanks ( ) Location & construction details ( ) ______________ ( ) ( )
6. **Distribution system piping (2)**—Kind, size & location of mains ( ) Valves, hydrants & blow-offs ( ) Extent of service ( ) ______________ ( ) ( )
7. **Existing cross connections (5)**—With unsafe source ( ) With reservoir or tank ( ) Between two approved sources ( ) Ordinance or policy filed with Health Department ( ) ______________ ( ) ( )

OPERATION

8. **Certified operator (9)**—Chief operator or superintendent ( ) Distribution system superintendent ( ) ______________ ( ) ( )
9. **Maintenance of equipment, buildings & grounds (5)**—Protective works at the source ( ) Low & high lift pumping equipment ( ) All buildings & grounds or other structures ( ) Cleanliness ( ) Maintenance of treatment units ( ) ______________ ( ) ( )
10. **Operation & laboratory control of treatment works (10)**—Systematic operation of all treatment facilities ( ) Laboratory control of treatment ( ) Bacteriological analysis ( ) ______________ ( ) ( )
11. **Operation of distribution system, reservoirs & tanks (4)**—Maintenance of valves, hydrants & other appurtenances ( ) Routine flushing of dead ends ( ) Disinfection of new works or existing works subjected to contamination ( ) Maintenance of reservoirs or tanks ( ) ______________ ( ) ( )
12. **Cross connection policy (5)**—Signed statement to Health Department ( ) Satisfactory administration of regulations ( ) ______________ ( ) ( )
13. **Cooperation with Department (5)**—Submission of reports ( ) Submission of plans & specifications for approval ( ) General attitude of cooperation ( ) ______________ ( ) ( )

WATER QUALITY

14. **Physical characteristics (5)**—Turbidity more than 5 p.p.m. ( ) Color more than 15 p.p.m. ( ) Taste & odor ( ) ______________ ( ) ( )
15. **Chemical characteristics (5)**—Calcium carbonate equilibrium ( ) Iron ( ) Manganese ( ) Fluoride ( ) Hardness ( ) ______________ ( ) ( )
16. **Bacteriological quality (10)**—Samples submitted in 12 months ( ) Positive samples ( ) ______________ ( ) ( )

Note: Defects marked with a cross (X)

Total score ______________

Signed ______________________

Title ______________________

APPENDIX F

Report of a Survey of the
Tennessee Department of Public Health
Division of Laboratories
Central Laboratory
Cordell Hull Building
6th Ave., North
Nashville, Tennessee 37219
on Sept. 15-16, 1970

by

Edwin E. Geldreich, Chief Bacteriologist
Bureau of Water Hygiene
U.S. Public Health Service
Cincinnati, Ohio 45213

The equipment and procedures employed in the bacteriological analysis of water by the laboratory conformed with the provisions of "Standard Methods for the Examination of Water and Wastewater" (12th edition, 1965) and with the provisions of the Interstate Quarantine Drinking Water Standards, except for items marked with a cross, "X", on the accompanying form PHS 875 (Rev. 1-66). Items marked with a "U" could not be determined at the time of the survey. Items marked "O" do not apply to the procedures programmed in the laboratory. Specific deviations are described with appropriate remedial action for compliance in the following recommendations:

1. Sampling Requirements

Sampling frequency for municipal supplies was examined from the records of the Central Laboratory (Nashville) and the two branch laboratories in Jackson and Knoxville with some observations presented in Table 1.

Table 1. Sampling Frequency for Selected Small Supplies

Municipal Supply	Date	Sample Location	Coliforms per 100 ml
Central Laboratory Records, Nashville			
Collinwood	Jan. 20, '69	Unknown	< 1
	Feb.	---*	---*
	Mar. 18	Unknown	< 1
	April	---*	---*
	May 6	Unknown	< 1
	May 27	"	< 1
	June 24	"	< 1
	July	---*	---*
	Aug. 5	Unknown	< 1
	Aug. 12	"	< 1
	Sept.	---*	---*
	Oct. 6	Unknown	< 1
	Oct. 14	Unknown	< 1
	Oct. 20	Unknown	54
	Oct. 27	Unknown	< 1
	Oct. 29	Dixon residence	< 1
	Nov. 18	Beauty shop	< 1
	Dec. 12	Barber shop	< 1
Knoxville Branch Laboratory Records			
Sneedville Utility District			
	Jan. 1, '70	---**	---**
	Jan. 13	Service Plant	60
	Jan. 16	" "	< 1
	Jan. 16	" "	< 1
	Feb. to Sept.	---***	---***
First Utility District of Knox Co.			
	April 2, '70	Northshore-Cowan Pk.	Positive
	May to Sept.	---***	---***
Pleasant Hill Utility District			
	July 15, '70	Unknown	78
	July 20	"	< 1
	Aug.-Sept.	---****	---****

*No samples collected during the month

**Sample too old in transit

***No other samples to date, Sept. 29, 1970

****No other samples taken at this location to date, Sept. 29, 1970

Apparently some small supplies were not sampled every month (Collinwood, Sneedville Utility District, and First Utility District of Knox Co.), location of samples were not recorded making evidence of resampling difficult to detect, and some evidence that sampling locations that did yield unsatisfactory results were not monitored again after one negative result was reported (Pleasant Hill Utility District).

Some effort was made, by a random cross section analysis, to study the sampling frequency for "Official Samples" submitted each month to the Division of Laboratories. The information reported in Table 2 indicates the number of "Official Samples" submitted by supplies serving populations over 5,000 is approximately 10 percent or less of the requirements specified in the Public Health Service Drinking Water Standards, Revised 1962. Sampling of the Gatlinburg municipal supply was also observed to remain at two per month during the summer months, regardless of the large influx of population related to the tourist season.

Table 2. Monthly Sampling Frequency for Public Water Supplies

Municipal Supply	Population Served	Samples per Month "Official Samples"*	Samples per Month Recommended Frequency**
Collinwood	596	1	2
Alexandria	599	2	2
Dandridge	829	2	2
Oliver Springs	1,163	2	2
Gatlinburg	1,764	2	2
Lake City	1,914	2	2
Joelton Water U. D.	4,000	4	4
La Follette	7,130	2	8
Knox-Chapman	7,780	2	8
Northeast Knox U. D.	10,000	2	14
Maryville	10,348	2	14
Athens	12,103	2	15
Oak Ridge	30,000	4	41
Knoxville	212,000	10	160
Nashville	261,000	18	180

*"Official Samples" includes those samples sent to either the Central Laboratory, the regional Branch Laboratory or both.

**Recommended Frequency of sampling based on population served (PHS Drinking Water Standards, Revised 1962).

3. Dechlorination

All sample bottles are prepared with the dechlorinating compound, sodium thiosulfate plus a chelation agent EDTA for possible metal ion toxicities that might be present in a given water source. These two agents are added in a mixed solution, 1 ml per sample bottle prior to bottle sterilization. Although the final concentration of 100 mg. sodium thiosulfate per liter is correct, the stock solution should be increased in concentration so that only 0. 5 ml of the mixed EDTA plus dechlorinating agent are needed per bottle. The one ml quantity does not evaporate to a dry residual in the sterile bottles and therefore may be lost through spill-out during inversion of bottles to get positioned under some faucet openings in confined spaces.

5. Remedial action for unsatisfactory samples

As recommended in the laboratory evaluation report of Dec. 5-6, 1967, whenever an unsatisfactory sample result is detected for municipal supplies, two additional sample bottles are sent to the operator with the report that includes the following statement:

> "Samples showing evidence of contamination require repeated testing from the same location until two successive negative results are obtained. Two sample bottles are being forwarded for immediate daily sampling."

Inspection of the laboratory reports in current files for 1969 revealed the following response from Joelton Water Utility District on repeat sampling requirements (Table 3).

Table 3. A Study of Response to Reports of Unsatisfactory Samples

Public Water Supply	Date Sampled	Sample Location	Coliforms per 100 ml	Date Rptd.
Joelton Water Utility District	May 21, '69	Clay Lick Road	13	June 3
	May 26	" " "	5	June 3
	June 5	" " "	< 1	--
		(No other sampling in 1969)		
		Ashland City Highway		
	June 12	Master Meter	< 1	--
	Aug. 12	Bailey Scott Grocery	2	Sept. 25
	Aug. 22	Master Meter	24	Sept. 25
	Sept. 12	Bailey Scott Grocery	2	Sept. 30
	Sept. 25	Bailey Scott Grocery	< 1	Sept. 30
	Sept. 25	Master Meter	2	Sept. 30

Table 3. (Continued)

Public Water Supply	Date Sampled	Sample Location	Coliforms per 100 ml	Date Rptd.
		Ashland City Highway		
Joelton Water Utility District	Sept. 26	Master Meter	2	--
	Sept. 30	Bailey Scott Grocery	< 1	--
	Oct. 9	Master Meter	2	Oct. 15
	Oct. 10	Bailey Scott Grocery	TNTC	Oct. 15
	Oct. 13	Bailey Scott Grocery	< 1	--
	Oct. 13	Master Meter	< 1	--
	Oct. 21	Master Meter	< 1	--
	Nov. 6	Bailey Scott Grocery	TNTC	Nov. 12
		(No other sampling in 1969)		
	Aug. 10	Knight Road	54	Sept. 25
	Sept. 13	" "	12	Oct. 15
	Sept. 25	" "	< 1	--
	Oct. 8	" "	13	Oct. 15
		(No other sampling in 1969)		

These data illustrate the lack of consecutive sampling from the same location on successive days till two negative results were secured. The table also illustrates the apparent slow processing of positive results by the Central laboratory reporting section. This backlog on filing has, in part, defeated efforts of the laboratory to give a rapid monitoring of water supplies through use of the faster membrane filter procedure. Inspection of the records in the Jackson and Knoxville Branch laboratories indicates record filing and reporting in these comparatively smaller laboratories to be current. Data in table 1 also indicate a lack of understanding by some sample collectors as to what constitutes the proper response to positive laboratory results.

9. Incubator

Incubator temperature control is not consistently meeting the ± 1.0°C tolerance at 35°C. It is suggested that an outboard electronic temperature regulator switch be installed for control within ± 1.0°C tolerance if the bimetalic strip in the incubator can not be stabilized. The accidental reduction in incubation temperature below 35°C will increase the problem of interference and false positives associated with non-coliform organisms common to unchlorinated supplies, well waters, lakes and some small streams. On the MF, Paracolobacterium species occur as the most frequent false positive, producing sheen reaction as a result of the partial breakdown of lactose. In general, we find these organisms grow better at temperatures below 35°C. False positive results in the multiple tube confirmed test may originate from several sources including anaerobic spore-formers of the *Clostridium welchii* type, spore-bearing aerobic forms related to *Bacillus subtilis* and to the symbiotic action of two different organisms.

State Water Laboratory Evaluation Program

Mr. Kenneth Whaley, Supervising Microbiologist for Water and Milk, has been the designated bacteriological survey officer of the Division of Laboratories for approximately 10 years. A review of this program activity indicates branch laboratories are evaluated every two years and the program has been expanded in recent years to include periodic visits to water plant laboratories at Alcoa, Chattanooga, Johnson City, Knoxville, Memphis, Nashville and Kingsport Consolidated Utility District.

With increasing activity in laboratory evaluation service, Mr. Whaley concluded it was desirable to train Mr. James Scott, Microbiologist, as an additional survey officer. Initial training included a joint survey of the Chattanooga Branch Laboratory on August 19, 1969. As part of the requested in-depth study of laboratories and their procedures, Mr. Scott participated in two joint (Federal-State) reviews of the bacteriological procedures used at the Knoxville Utilities Board, Mark B. Whitteker water plant, September 29, 1970 and the Knox-Chapman Utilities District water plant, September 30, 1970.

Mr. Scott is familiar with coliform detection methods, laboratory apparatus, media requirements, and analysis of laboratory records for compliance of sampling to meet Public Health Service requirements in water quality standards. During my two-day conference on laboratory procedures at the Central Laboratory and in our joint visit to two water plant laboratories in the Knoxville area, Mr. Scott demonstrated the qualities of temperament desirable to obtain the cooperation of laboratory personnel in improving their procedures where necessary, without incurring a feeling of resentment.

The current evaluation status for water laboratories by the Tennessee Department of Public Health is given in Table 4.

Table 4. Current Evaluation Status for Water Laboratories in Tennessee

Laboratory and Location	Survey Officer	Survey Date
Tennessee Branch Laboratories		
Chattanooga Branch Laboratory Chattanooga, Tenn. 37403	J. Scott & K. Whaley	8/19/69
Jackson Branch Laboratory Jackson, Tenn. 38301	K. Whaley	11/10, 13/69
Johnson City Branch Lab. Johnson City, Tenn. 37601	K. Whaley	5/13-15/70
Knoxville Branch Laboratory Knoxville, Tenn. 37902	K. Whaley	10/23/69
Memphis Branch Laboratory Memphis, Tenn. 38103	K. Whaley	2/4-5/70
Water Plant Laboratories		
Alcoa Water Plant	K. Whaley	12/4-5/69
Chattanooga Water Plant	K. Whaley	5/26/70
Johnson City Water and Sewerage Treatment	K. Whaley	10/25/66
Knoxville Utilities Board	E. Geldreich & J. Scott	9/29/70
Knox-Chapman Utilities	J. Scott & E. Geldreich	9/30/70
Nashville Water Plant	K. Whaley	2/1, 15/67
Consolidated Utility District, Kingsport	K. Whaley	2/8/67

Water plants that are known to be performing some bacteriological examinations of their water supplies for quality control but which have never been evaluated are listed in Table 5.

Table 5.
Water Plant Laboratories in Tennessee that Have Never Been Evaluated

Water Plant	County	Water Connections	Bacteriological Procedures
Athens	McMinn	3,926	MF
Big Creek U. D.	Grundy	803	MF
Bloomingdale	Sullivan	2,000	MF
Bolivar	Hardeman	1,250	MF
Bristol	Sullivan	7,800	MF
Bristol-Bluff City U. D.	Sullivan	975	MPN
Camden	Benton	1,250	MF
Carthage	Smith	750	MF
Cleveland	Bradley	8,041	MF
Clinton	Anderson	1,550	MF
Cocke Co. U. D.	Cocke	550	MF
Columbia	Maury	7,094	MPN
Cookerville	Putnam	4,000	MF
Crossville	Cumberland	1,535	MF
Cumberland Water Co.	Davidson	1,350	MPN
Daisy-Soddy Falling Water U. D.	Hamilton	2,250	MF
Dickson	Dickson	2,000	MPN
Dunlap	Sequatchie	675	MF
Dyersburg	Dyer	4,568	MPN
Dyersburg Sub. Cons. U. D.	Dyer	684	MPN
Erwin	Unicoi	2,800	MF
Etowah	McMinn	1,809	MPN
Fayetteville	Lincoln	3,000	MPN
Franklin	Williamson	3,400	MPN
Gallatin	Sumner	4,000	MF
Gatlinburg	Sevier	1,068	MF
Greeneville	Greene	5,000	MF
Hallsdale-Powell U. D.	Knox	4,345	MF
Harpeth Valley U. D.	Davidson	768	MF
Harriman	Roane	2,875	MPN
Hartsville	Trousdale	683	MF
Huntington	Carroll	1,200	MF
Jefferson City	Jefferson	1,425	MF
Kingsport	Sullivan	12,500	MF
Kingston	Roane	1,304	MPN

Table 5. (Continued)

Water Plant	County	Water Connections	Bacteriological Procedures
LaFollette	Campbell	2,300	MF
Lawrenceburg	Lawrence	3,100	MPN
Lebanon	Wilson	4,048	MPN
Lenoir City	Loudon	1,770	MF
Lewisburg	Marshall	2,800	MF
Lexington	Henderson	1,000	MF
Livingston	Overton	1,150	MF
Madison Sub. U.D.	Davidson	11,000	MPN
Manchester	Coffee	1,900	MPN
Martin	Weakley	2,000	MF
Maryville	Blount	4,617	MF
McMinnville	Warren	3,904	MF
Memphis	Shelby	160,000	MPN
Millington	Shelby	1,800	MPN
Morriston	Hamblen	6,916	MF
Murfreesboro	Rutherford	6,398	MF
New Providence U.D.	Montgomery	2,600	MF
North Anderson Co. U.D.	Anderson	1,509	MF
Northeast Knox U. D.	Knox	2,500	MF
Oak Ridge	Anderson	17,000	MPN
Old Hickory U. D.	Davidson	1,300	MF
Oneida	Scott	775	MF
Paris	Henry	3,771	MPN
Pulaski	Giles	2,489	MPN
Rockwood	Roane	2,100	MF
Rogersville	Hawkins	1,500	MF
Sevierville	Sevier	760	MF
Shelbyville	Bedford	4,083	MPN
Smyrna	Rutherford	1,200	MF
South Cheatham U. D.	Cheatham	550	MF
Sparta	White	2,300	MF
Springfield	Robertson	2,900	MF
Sweetwater	Monroe	1,600	MF
Tullahoma	Coffee	4,300	MPN
Turnbull U. D.	Dickson	300	MF
Union City	Obion	3,850	MF
West Knox U. D.	Knox	2,096	MF
West Wilson Co. U.D.	Wilson	1,013	MPN
White House U.D.	Robertson	1,450	MPN
Whitehaven U.D.	Shelby	10,700	MF
Winchester	Franklin	2,000	MPN
Woodbury	Cannon	761	MF

In an effort to obtain a cross section review of bacteriological procedures in water plant laboratories, three specific categories described in Table 6 were chosen and evaluations were performed in September 1970.

Table 6. Tennessee Water Plant Laboratories Evaluated

Name	Service Connections	Evaluation by State
Jackson Water Utility	14,050	None
Knoxville Utilities Board	53,000	Dec. 3, 1969
Knox-Chapman Utilities District	1,945	None

Evaluation of the procedures used in the Jackson water plant laboratory (Jackson Water Utility) revealed that no dechlorination agent was ever added to sample bottles. Chlorine residual was reported to average 0.1 mg/liter in distribution samples. The frequency of sampling water plant finished water and sampling the distribution system water quality was skewed by collecting only finished waters for three days and distribution samples only on the other two days. The technician (1 year of college) was taught to use the MF procedure by the water plant operator. The water plant operator gained his knowledge of the MF technique from a one day demonstration course given by the Millipore Filter Corporation regional representative. The Jackson Branch laboratory of the Tennessee Department of Health has never been consulted by the water plant personnel on MF methods nor has any effort been made by this state laboratory staff to visit the filter plant laboratory in the past.

The Knoxville Utilities Board (Mark B. Whitteker Water Plant) laboratory is well equipped and is staffed by two graduate chemists and a technician with previous laboratory experience. Their laboratory procedures have been previously evaluated and found to be acceptable by Mr. Whaley in his evaluation, December 1969. Our laboratory evaluation indicated that the deviations noted by Mr. Whaley had either been corrected immediately or as soon as specified equipment was obtained.

The Knoxville-Chapman Utilities District does perform a limited number of chemical and bacteriological tests on the raw water, treatment processes and the finished product. All tests are performed by the water plant operator whose knowledge has been acquired from several water plant operator courses and by reference to an outline of laboratory procedures prepared in 1957 by the Tennessee Department of Public Health. There has never been an effort made by the State water laboratory evaluation service to examine the procedures, equipment and staff ability of the numerous small water plants that desire to test water for their needs in control processing.

The need for further training in laboratory procedures by some personnel at small water plants can be illustrated from our observations at the Knox-Chapman water plant. Study of plant records indicates no coliforms have been reported in the finished water for a period of years. Inspection of the MPN procedures shows the reason to be related to use of nutrient broth in the presumptive test instead of lactose broth. Nutrient broth does not contain a fermentable carbohydrate thus no gas will ever be found in these fermentation tubes. What was more remarkable was the record of positive results using the same medium on raw samples. Apparently the operator is convinced that these raw water MPN results must be positive and is recording results as such. I saw no positive cultures among any of the MPN tubes being incubated beyond 24 hours during the day of our visit. Inquiry made at the Knoxville Branch Laboratory of the Tennessee Division of Laboratories indicated Mr. Shipe had made a short visit to the Knox-Chapman water plant some five or six years ago but no formal evaluation of procedures was ever made prior to our visit September 30, 1970.

A cross-section study of water plant laboratories demonstrates the need for a more comprehensive laboratory evaluation service. Every effort should be made by designated state laboratory survey officers to up-grade methods and equipment used in small water plant laboratories. This could be accomplished by recommending procedural improvements that would lead to increased test sensitivity; assisting with on-site training when feasible; encouraging visits to the State laboratory for an on-the-job training period of several days; and establishing a direct communication link between personnel of these two levels of laboratory competencies. Although the personnel of these small laboratories may not have a background of scientific training, per se, they are eager to learn and to perform the bacteriological control testing properly.

Legal responsibility for the Tennessee State Laboratory Survey Program is with the Division of Sanitary Engineering. As a cooperative effort, evaluations are done by a designated microbiologist in the Division of Laboratories who also supervises the water and milk laboratory. Any expansion of the evaluation service will require the use of two approved survey officers and this problem has been solved in the selection and certification of both Mr. Kenneth Whaley and Mr. James Scott. There is also a recognized need for clerical help specifically assigned to the water and milk laboratory to type laboratory evaluation reports, record and report laboratory results on water examinations sent to the Central Laboratory, and to type correspondence generated with water plants under the proposed expansion of this state service.

Since there are approximately 85 laboratories that have never been evaluated, it is proposed that the grouping be sorted by counties covered by the State Branch Laboratory service. All initial visits should be made by the Branch Laboratory Director or his delegated microbiologist to establish a communication line within his region and to determine which laboratories need urgent priority attention to up-grade major problems in procedures, equipment needs and personnel knowledge.

Coverage of all laboratories that examine potable water should eventually include not only all municipal water plant laboratories but any hospital, university, or commercial laboratories in Tennessee that examine potable waters for compliance with PHS Drinking Water Standards and State regulations.

Remarks

Space

The laboratory bench space will have to be increased if the monitoring of water, milk and food is increased as anticipated. Currently water and milk samples must be scheduled to use the same limited available bench space in one laboratory during different times in the day. Part of a second assigned laboratory room is used for clerical work by the staff microbiologists who spend several hours each day recording "PK" testing results. When clerical help is made available for the laboratory evaluation service, this same office personnelcould be trained to do the "PK" recording and report filing, thus releasing the microbiologists for use in the projected increase in environmental monitoring service.

Distilled Water

Distilled water used in the water and milk laboratory is brought by carboy from the fourth floor to the preparation rooms and laboratory. The central distilled water system in the building has been modified for delivery of demineralized water through the relatively new block tin lines. The water and milk laboratory has examined the biological suitability of the demineralize water and found it to be in a toxic range of 0.35 to 0.2. Double distilled water used to prepare media and dilution blanks has been shown to be of excellent quality (0.8 to 1.0) in terms of the distilled water suitability test.

For purposes of supplying a good quality distilled water for use by all laboratory activities, it is recommended that the central still be inserted in the output of the demineralizer and this product water be distributed through the central distribution lines of block tin. Availability of a good quality distilled water does require monitoring. Some laboratory staff member should be assigned responsibility to maintain the distilled water quality through daily checks of conductivity, periodic recharging of the demineralizer, control of production capacity to have a reservoir supply available, yearly inspection of valves, electrical heating elements, storage tank and distribution lines for defects plus a yearly suitability test to measure the biological suitability of the distilled water quality. This biological procedure should be done by the staff microbiologists in the water and milk program.

Water Bath

Expanding use of the fecal coliform procedure for use in monitoring natural bathing waters during the summer months has created the need for a suitable water bath capable of maintaining water temperature at 44.5°C ± 0.2°C. The available water bath is small and is difficult to maintain any closer than ± 0.5° C when adjusted for the required elevated temperature incubation.

There are several circulating water baths available commercially that will hold the ± 0.2° C tolerance at 44.5° C. Blueprints of an excellent unit developed by personnel of the Alabama State Health Department can be obtained in a request to Dr. Hosty, Director of Laboratories. If local shop metal workers are experienced in stainless steel construction, a copy of the Alabama water bath may be constructed at some saving in cost and fully meet the needs of such a unit in water and food examinations.

Personnel Approved

Mrs. Dianne Brown, Mrs. Helen Nelson, Mr. Robert Ball and Mr. James Scott, Microbiologist in the water and milk laboratory are approved for the application of the total coliform and fecal coliform membrane filter and multiple tube procedures to the bacteriological examination of both potable water and natural bathing water quality measurements.

Conclusions

The procedures and equipment in use at the time of the survey complied in general with the provisions of Standard Methods for the Examination of Water and Wastewater (12th Edition, 1965) and the Public Health Service Drinking Water Standards and with correction of deviations listed, it is recommended that the results be accepted for the bacteriological examination of potable waters under interstate regulations.

Edwin E. Geldreich
Consulting Bacteriologist

EPARTMENT OF HEALTH, EDUCATION, AND WELFARE
[illegible] HEALTH SERVICE

urvey Form for Water Laboratories (Bacteriological)

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PHS-[illegible] (Rev. 1-66)

Indicating conformity with Public Health Service Drinking Water Standards

URVEY BY Edwin E. Geldreich

X=DEVIATION U=UNDETERMINED 0=NOT USED

ABORATORY Tennessee Dept. of Public Health, Division of Laboratories, Central Laboratory

LOCATION Cordell Hull Building Nashville, Tenn. 37219

DATE Sept. 15-16,1970

SAMPLES

1. **Sampling** ....
   - Representative points throughout distribution system ....
   - Location and frequency of sampling adequate X
   - Minimum number monthly adequate for population X
   - Repetitive samples from designated points as well as others to establish bacteriological quality throughout system ....
   - Proportionately more samples from small population areas ....
2. **Collection Procedure** ....
   - Volume necessary for all tests ....
   - Minimum sample not less than 100 ml ....
   - Ample air space shall be left in bottle to facilitate mixing ....
   - Representative sample collected without contamination ....
   - Tap sample collected from tap connected directly to main by service pipe ....
   - Do not collect sample from tap connected to storage tank ....
   - Tap allowed to waste water until service line has been cleared ....
   - River, stream, lake, or reservoir sample collected by plunging opened bottle with neck downward below surface ....
   - Collect with mouth and toward current (or away from hand) ....
   - Pump allowed to waste water 5 min before taking sample ....
   - Promptly identify sample legibly and indelibly ....
   - Complete and accurate data accompanies sample ....
3. **Dechlorination** X
   - Sodium thiosulfate used for dechlorination ....
   - Added before sterilization of bottle ....
   - Concentration approximately 100 mg/l ....
4. **Transportation and Storage** ....
   - Temperature maintained as close as possible to the water temperature at time of collection ....
   - Initiate examination as soon as possible after collection ....
   - Recommended time within 1 hr after collection ....
   - Time between collection and examination not exceeding 30 hr ....
   - Establish field procedure where time exceeds 24 hr ....
   - Time and temperature of storage recorded ....
5. **Remedial Action For Unsatisfactory Sample** X
   - If three or more positive tubes per test, or ....
   - one ~~Four~~ or more coliforms per 100 ml by membrane filter ....
   - Daily samples from point promptly examined until two consecutive samples are satisfactory ....
6. **Record of Laboratory Examinations** ....
   - Results assembled and available for inspection ....
   - Consistent compliance with water quality standards ....
   - Laboratory methods and technical competence of local government, waterworks, and commercial laboratories approved by reporting agency ....

LABORATORY APPARATUS

7. **Sample Bottles** 4 oz. (125 ml) ....
   - Glass resistant to solvent action of waters ....
   - Plastic sample bottles which may be sterilized and yield no toxic substances ....
   - Holds sufficient sample with air space for all necessary bacteriological tests, maintains sample uncontaminated ....
   - Closure: ....
     - a. Glass stopper covered, before sterilization, with metal foil, rubberized cloth, or heavy impermeable paper ....
     - b. Metal or plastic screw cap with leak-proof liner, provided both are free from toxic substances on sterilization ....
8. **Thermometer** ....
   - Accuracy checked with thermometer certified by National Bureau of Standards, or one of equivalent accuracy ....
9. **Incubator** NAPCO Model 320
   - Maintain uniform temperature in all parts (±1.0° C) X
   - Either water-jacket (filled) or anhydric type, with low-temperature, thermostatically controlled electric heating units properly insulated and located in or adjacent to walls or floor ....
   - Provided with shelves so spaced as to assure uniformity of temperature ....
   - Sufficient size (provide 1-in. space between walls, dishes, or baskets) ....
   - Accurate thermometer with bulb immersed in liquid on each shelf ....
   - Daily record of temperature, or ....
   - Optionally use automatic devices of predetermined accuracy for recording temperatures ....
   - Unless recording thermometers are in continuous operation, preferably install maximal and minimal registering thermometer on middle shelf to record temperature variations over 24-hr period ....
   - At intervals determine temperature variations within incubator when filled to maximal capacity ....
   - Keep where temperatures do not vary excessively (50-80°F) ....
10. **Incubator Room** .... O
    - Optionally use walk-in rooms, well insulated, equipped with properly distributed heating units and forced-air circulation ....
    - Provided areas conform to desired temperature limits ....
    - Record daily range in temperature in areas used for plates ....
11. **Hot-Air Sterilizing Oven** Precision
    - Size sufficient to prevent crowding of interior ....
    - Constructed to give uniform and adequate sterilizing temperatures (check temperature variations within oven) ....
    - Equipped with thermometer registering accurately at 160-180° C ....
    - Recording thermometer (optional) ....
12. **Autoclaves** .... Castle
    - Size sufficient to prevent crowding of interior ....
    - Constructed to provide uniform temperatures up to and including 121° C ....
    - Equipped with accurate thermometer with bulb properly located to register minimal temperature within chamber ....

PHS-875
(Rev. 1-66)

Laboratory Apparatus (continued)

Recording thermometer (optional) .... ____
Pressure gages and properly adjusted safety valve .... ____
Connected with saturated-steam line, or to gas or electrically heated steam generator .... ____
Reach sterilizing temperature in ~~30~~ 5 min .... ____
Small pressure cookers may be substituted only in emergencies and only where satisfactory results have been demonstrated .... ____
And provided pressure cooker has pressure gage and thermometer with bulb 1 in. above water level .... ____

13. Colony Counter .... ____
Quebec colony counter, dark-field model preferred .... ____
Or one providing equivalent magnification and visibility .... ____

14. pH Equipment Beckman Zeromatic .... ____
Electrometric pH meter shall be used for pH of media .... ____

15. Balances Torsion Balance .... ____
a. Balance with sensitivity of 2 g at 150-g load shall be used .... ____
Appropriate weights of good quality .... ____
b. Analytical balance with sensitivity of 1 mg at 10-g load .... ____
Appropriate analytical grade weights .... ____
Used for weighing quantities less than 2 g .... ____

16. Media Preparation Utensils .... ____
Borosilicate glass .... ____
Stainless steel .... ____
Other noncorrosive utensil .... ____
Clean and free from foreign residues or dried agar .... ____
Free from toxic or foreign materials which may contaminate media (such as detergents, chlorine, copper, zinc, antimony, or chromium) .... ____

17. Pipets Kimax .... ____
Deliver accurately and quickly .... ____
Calibration error not exceeding 2.5% .... ____
Tips unbroken, graduation distinctly marked .... ____
Mouth end plugged with cotton (optional) .... ____
Pipets conforming to APHA specifications (S. M. Exam. Dairy Prod. 11th ed.) may be used (optional) .... ____

18. Pipet Containers .... ____
Box, aluminum or stainless steel, 2-3 x 16 in. .... ____
Paper wrappings of good quality sulfite paper (optional) .... ____
Copper cans or boxes prohibited .... ____

19. Dilution Bottles or Tubes .... ____
Borosilicate or other noncorrosive glass .... ____
Glass stopper or rubber rattail .... ____
Screw cap with leak-proof liner free from toxic substances on sterilization .... ____
Cotton plugs prohibited .... ____
Graduation level indelibly marked on side of bottle or tube .... ____
Non-toxic plastic bottles may be substituted .... ____

20. Petri Dishes .... ____
Clear bottom, free from bubbles and scratches .... ____
Diameter 100 mm x 15 mm high (60 x 15 mm for M.F.) .... ____
Bottom flat for medium of uniform thickness .... ____
Glass or porous top .... ____
Presterilized plastic dishes proven free from toxic substances and sterile may be substituted for single use only .... ____

21. Petri Dish Containers .... ____
Used to protect and handle before and after sterilization .... ____
Aluminum or stainless steel (not copper) cans with covers, [illegible], woven wire baskets or char-resistant paper [illegible] .... ____

22. Fermentation Tubes .... ____
Sufficient size to conform with requirements for concentration of nutrient ingredients and sample as described subsequently .... ____

PREPARATION

23. Cleaning Glassware "Better Built" .... ____
Thoroughly washed with suitable detergent and hot water (160° F) Tennessee State Industries .... ____
Rinsed in clean water at 180 °F to remove detergent .... ____
Rinsed with distilled water .... ____
Freedom from any residue on drying .... ____
Free from acidity or alkalinity .... ____
Detergent leaves no toxic residue .... ____

24. Sterilization of Glassware .... ____
Heat glassware not in metal containers for not less than 60 min at 170° C 2 hrs. at 175° C .... ____
Optionally use 160° C for 60 min with constant temperature recording device if oven temperatures are uniform .... ____
Heat glassware in metal containers for not less than 2 hr at 170° C .... ____
Non-plastic sample bottles as above, or .... ____
Autoclave at 121° C for ~~15~~ 45 min No steam exhaust .... ____
Plastic sample bottles that distort on autoclaving sterilized by low-temperature ethylene oxide gas .... ____

25. Buffered Dilution Water .... ____
Stock phosphate buffer solution at pH 7.2 .... ____
Freshly prepared when stock solution shows trace of turbidity .... ____
Optionally autoclave stock buffer and store in refrigerator .... ____
1.25 ml of stock buffer added to 1 liter distilled water .... ____
Dispense to give 99± 2 ml or 9± 0.2 ml after autoclaving .... ____
Sterilized in autoclave at 121° C for ~~15~~ 30 min .... ____
Quantity after sterilization with 2% or less deviation .... ____
Dilution volumes of 9 ml may be measured aseptically .... ____

MEDIA — MATERIALS AND PROCEDURES

26. Water .... ____
Distilled or demineralized water used for media, reagents, blanks, etc. .... ____
Free from traces of dissolved metals or chlorine .... ____
Neutralize distilled water if free chlorine is present .... ____
Free from bactericidal compounds as measured by bacteriological suitability test using *Aerobacter aerogenes* .... ____

27. Media Ingredients .... O
Beef extract .... ____
Yeast extract .... ____
Peptone .... ____
Sugars .... ____
Agar .... ____
Above preparations demonstrated to give satisfactory results for bacteriological purposes .... ____

28. General Chemicals .... ____
Reagent or ACS grade .... ____

29. Dyes .... ____
Certified by the Biological Stain Commission for use in media .... ____

30. Storage .... ____
Dehydrated media stored tightly in dark (low humidity) at less than 30° C .... ____
Not used if discolored or caked .... ____
Culture media stored in clean, dry space free from contamination and excessive evaporation .... ____

NCUI-132 (Cin)
(5-68)

Survey Form for Water Laboratories (Bacteriological)

X=DEVIATION U=UNDETERMINED O=NOT USED

LABORATORY Tennessee Dept. of Public Health, Division of Laboratories, Central Laboratory

LOCATION Cordell Hull Building Nashville, Tenn. 37219

DATE Sept. 15-16, 197

Media — Materials and Procedures (continued)

Batches used in less than 1 week
Protected from strong light
Fermentation tubes stored at room temperature not over 1 week
Fermentation tubes stored at low temperatures must be incubated overnight and tubes with air bubbles discarded

31. Adjustment of Reaction
Expressed in concentration of hydrogen ions (pH)
Determine decrease in pH of individual medium in the autoclave used for its sterilization
Potentiometric method recommended for accurate determination
Appropriate standard buffer used to calibrate pH meters
Colorimetric method not used with media containing dyes
Indicator solution prepared to match color standards
Calibrated against standard buffer pH 7.0
Follow standard procedure, using a comparator

32. Sterilization of Media
All media, except sugar broths, autoclaved at 121° C for 15 min
Timing starts when autoclave reaches 121° C temperature
Media removed and cooled as soon as possible after sterilization
Tubes packed loosely in baskets for uniform heating and cooling
Carbohydrate broths sterilized as above for 10 min
Optionally add sterilized carbohydrate solution aseptically to sterile media
Incubate tubes so prepared at 35° C for 24 hr before use
Total exposure of carbohydrate media to heat not over 25 min

33. Clarification O
Use filtration, sedimentation, or centrifugation as needed
Do not clarify with nutrient substances such as egg albumen

CULTURE MEDIA — SPECIFICATIONS

34. Per Cent Solution
Use grams solute per 100 ml of solution

35. Nutrient Broth O
Correct composition, sterility, and pH (6.8-7.0)

36. Lactose Broth
Correct composition, sterility, and pH (6.9±0.1)
Tubed in proper sized tube with inverted vial
Total time of exposure to any heat not more than 30 min
When quantities greater than 1 ml are planted, composition after planting will contain 0.013 g per ml of dry ingredients
Not less than 10 ml medium per tube
Dehydrated medium used. Brand Difco Lot No. 426838

37. Lauryl Tryptose Broth O
Correct composition, sterility, and pH (6.8 ± 0.1)
Complies with general requirements described above
When quantities greater than 1 ml are planted, composition after planting will contain 0.0356 g per ml of dry ingredients
Dehydrated medium used. Brand Lot No.

38. Brilliant Green Lactose Bile Broth
Correct composition. Brand Difco Lot No. 428855
Dehydrated ox gall only used in medium
Ox gall solution (10% in distilled water) has pH of ~~7.0 to 7.5~~ pH 7.4
Add 13.3 ml 0.1% solution brilliant green/l of medium

Sterile medium has pH of 7.1 to 7.4 (electrometric method only)

39. Endo Medium O
Formula I used or
Formula II used
Correct composition, sterility, and pH (7.4 ± 0.1)
Proper reaction when seeded with coliforms
Dehydrated medium used. Brand Lot No.

40. Eosin Methylene Blue Agar O
Correct composition, sterility, and pH (7.1 ± 0.1)
Proper reaction when seeded with coliforms
Medium contains no sucrose. Catalog No
Dehydrated medium used. Brand Lot No.

41. Tryptone Glucose Beef Extract Agar O
Tryptone Glucose Yeast Extract Agar
Correct composition, productivity, sterility, and pH (7.0 ± 0.1)
Sterile medium not remelted a second time after sterilization
Free from precipitate
Dehydrated medium used. Brand Difco Lot No. 534456

42. M-Endo Medium
Correct composition. Brand Difco Lot No. 538132
Prepare in clean presterilized borosilicate glassware
Reconstituted in distilled water containing 2% ethyl alcohol
Heated to boiling point (do not boil or submit to steam pressure)
pH between 7.1 and 7.3
Stored in dark at 2-10° C
Unused medium discarded after 96 hr

43. M-Endo Agar Medium O
Correct composition. Brand Lot No.
Reconstituted in distilled water containing 2% ethyl alcohol
Heated to boiling point (do not boil or submit to steam pressure)
pH between 7.1 and 7.3
Cool to 45-50° C and dispense 4 ml in 60-mm dishes
Keep plates in dark at 2-10° C (may store 2 weeks)

TESTS FOR PRESENCE OF MEMBERS OF COLIFORM GROUP BY MULTIPLE-TUBE FERMENTATION TECHNIQUE

44. Presumptive Test Use only on turbid samples
Lactose broth or
Lauryl tryptose broth O
Before planting portions arrange tubes in order, number sample, or otherwise identify
Shake sample vigorously 25 times before removing portions
Inoculate fermentation tubes with appropriate quantities
Use 5 standard portions, either 10 or 100 ml
Concentration of ingredients conform to items 36 or 37
Quantities inoculated: 10 ml 5 1 ml --- 0.1 ml ---
Incubate tubes at 35 ± 0.5° C for 24 ± 2 hr
Examine for gas — any gas bubble positive
Return negative tubes to incubator
Examine for gas at 48 ± 3 hr from original incubation
Record presence or absence of gas at each examination
Gas in any quantity in 48 ± 3 hr is positive Presumptive Test
No gas in 48 ± 3 hr is negative test
Do not record gas produced after 51 hr of incubation

45. Confirmed Test

Promptly submit all presumptive tubes showing gas production before or at 24-hr and 48-hr periods to Confirmed Test

a. Brilliant green lactose bile broth

Gently shake tube or mix by rotating

Transfer one loopful of positive broth to brilliant green bile...

Using sterile loop of 24-gage wire not less than 3 mm diameter

Incubate for 48 ± 3 hr at 35° ± 0.5° C

Formation of any gas in the inverted vial within 48 ± 3 hr constitutes a positive Confirmed Test

b. Endo or eosin methylene blue agar plates O

Streak one or more plates with inoculum from positive primary fermentation tube(s)

Use inoculating needle slightly curved at tip

Tap and incline tube to avoid any scum

Insert needle approximately 5 mm

Streak agar surface with curved section

To obtain discrete colonies separated by at least 0.5 cm

Incubate at 35° ± 0.5° C for 24 ± 2 hr

If typical nucleated colonies with or without sheen develop, the Confirmed Test is positive

If atypical, unnucleated pink colonies develop, result is doubtful and Completed Test must be applied

If no colonies or only colorless colonies without mucoid characteristics, the Confirmed Test is negative

c. Alternate application with multiple portions and dilutions

Optional only with three or more decimal dilutions

Submit to Confirmed Test all positive tubes of two highest dilutions (smallest volumes) occurring in 24 hr

Record any tube showing gas in 24 hr which has not been confirmed as positive Confirmed Test

Submit to confirmation all tubes negative at 24 hr and positive in 48 hr (no exception)

46. Completed Test

Applied to positive Confirmed Test fermentation tubes or

To doubtful appearing colonies on differential plate medium

If from liquid medium, streak as in Item 45b

Fish one or more typical colonies to transfer to lactose or lauryl tryptose broth tube and to an agar slant or

Fish two or more atypical colonies as described above

Choose colonies separated by 0.5 cm

Incubate at 35° ± 0.5° C for 24 ± 2 or 48 ± 3 hr

Examine agar slant with Gram-stain if corresponding secondary lactose broth showed gas in 24 or 48 hr

Gram-negative rods without spores and gas in lactose tube is positive Completed Test

Absence of gas in lactose tube in 48 hr — negative test

Only Gram-positive bacteria in stain — negative test

47. Application of Tests to Routine Examination

a. Presumptive Test applied to:

Samples not being considered for drinking water

Routine raw water quality where applicable in plant

b. Confirmed Test applied to:

Waters to which Presumptive Test is not applicable

Routine samples of drinking water process or finished water

Chlorinated sewage effluents

Bathing waters

c. Completed Test applied to:

Examination of water samples where results are to be used for the control of the quality of raw or of finished waters

If not applied to all such samples, then applied to such a proportion as to establish beyond reasonable doubt the value of the Confirmed Test in determining their sanitary quality

48. Number of Tests . er Year

Presumptive Total + −

Confirmed Total + −

Completed Total + −

TESTS FOR PRESENCE OF MEMBERS OF COLIFORM GROUP BY MEMBRANE FILTER TECHNIQUE

49. Application As Standard Test

Use as a standard test for determining potability of water after demonstration by parallel testing that it yields information equal to that from the multiple-tube fermentation procedure

Examine not less than 50-ml sample

50. Laboratory Apparatus (See items 7, 17-21)

Graduated cylinders accurate within 2.5% and

Openings covered with Kraft paper or substitute before sterilization

Use glass containers for culture medium

Filtration unit — any type that can be sterilized

Filters all the sample through the membrane

Vacuum source (water trap to protect pump desirable)

Funnel and filter receptacle wrapped separately for sterilization and storage

51. Filter Membranes Millipore

Full bacterial retention, satisfactory speed of filtration

Stable in use, glycerin free, free from substances toxic to growth

Preferably grid marked, non-toxic ink

Adequately protected during sterilization from recontamination

Autoclaved at 121° C for 10 min (or presterilized)

52. Absorbent Pads Millipore

Filter paper free from growth inhibitory substances

Approximately 48 mm diameter

Thickness will permit absorbing 1.8 - 2.2 ml medium

Sterilized before using in test (121° C for 10 min)

53. Forceps

Round tipped, without corrugations

Membranes and pads handled with sterile (alcohol flamed) forceps

54. Microscope and Lamp

Preferably binocular wide field, 10 to 15 diameters magnification

Fluorescent light, adjacent, above, perpendicular to filter plane

Other optical device giving equivalent results

55. Filtration

Suitably disinfect bench surface, allow to dry

Filter holding unit sterile at start of series

Use support for inverted funnel between samples (optional)

Place sterile membrane on porous plate, secure funnel

Apply vacuum, filter appropriate sample volume (number of tests uncountable not excessive) and rinse funnel

By filtering 3 volumes of 20-30 ml of sterile buffered water

Remove filter with sterile forceps

56. Standard Test — Single Step

a. Broth—Sterile pad placed in culture dish

Saturated with M-Endo medium (42)

Allow to stand a few minutes before pouring off excess

Prepared filter (55) rolled (grid side up) onto pad

b. Agar—Use culture dish previously prepared (43) O

Prepared filter (55) placed on agar with rolling motion

NCUI-132 (Cin)
(5-68)

Survey Form for Water Laboratories (Bacteriological)

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LABORATORY Tennessee Dept. of Public Health, Division of Laboratories, Central Laboratory
LOCATION Cordell Hull Building Nashville, Tenn. 37219
DATE Sept. 15-16,197

Tests for Presence of Members of Coliform Group by Membrane Filter Technique (continued)

57. Standard Test — with Enrichment O
Sterile pad placed in culture dish
Saturated with approximately 1.8 ml enrichment medium (37)
Carefully remove any excess liquid
Prepared filter (55) placed on pad
Incubate inverted filter at 35° ± 0.5° C for 1½-2 hr
Remove dish from incubator and remove top
a. Broth — With sterile forceps lift pad and filter to top of dish
Place new sterile pad on bottom and saturate with medium (42)
Transfer filter to new pad (and discard used pad)
b. Agar — With sterile forceps strip filter from pad
Roll onto surface of previously prepared agar (43)
Optionally leave used pad in dish to maintain humidity

58. Incubation
In saturated humidity, with dish inverted
At 35° ± 0.5° C, for 22-24 hr
Incubate enriched tests for 20-22 hr

59. Counting
Count all dark colonies with sheen as coliform colonies
If only atypical forms, establish identity
Calculation of direct count in density per 100 ml

60. Number of Tests Per Year
Membrane Filter Total + —

MISCELLANEOUS

61. Recommended Laboratory Practices
Personnel adequately trained or supervised
Copy of Standard Methods (12th ed.) available in laboratory
Level table or bench, ample working surface
In clean, well-lighted, well-ventilated room, reasonably free from dust and drafts
Floors clean, walls and ceilings smooth
Doors and windows screened, or insects and rodents absent
Space adequate, free from confusion
Used for laboratory purposes only
Table space, storage and utilities adequate
Cabinets, shelves, and equipment neat, clean, and orderly
Clean outer garments worn
Clothing stored outside laboratory or in closet
Safety precautions and practices satisfactory

SUPPLEMENTARY BACTERIOLOGICAL METHODS

Applicable to non-potable surface, process and bathing waters, effluents, sea water, and shellfish.

STANDARD PLATE COUNT

62. Sample Agitation on request only
Shaken vigorously 25 times immediately before removing portion
Each dilution shaken 25 times

63. Plating
Appropriate quantity of sample per plate
In highly polluted waters use dilutions in sterile dilution water
Plate not more than 1 or less than 0.1 ml (sample or dilution)
Add to each dish 10 ml or more liquefied agar medium
At temperature of 43-45° C
Melted medium stored for no more than 3 hr, 43-45° C
Gently lift cover of petri dish only high enough to pour medium
Agar and test portions thoroughly mixed, by rotating and tilting without splashing and mixture spread evenly
Allow to solidify within 5-10 min on level surface
Invert (unless clay tops are used) and promptly incubate
Not more than 20 min between measuring sample and pouring

64. Incubation
Arrange so each plate or pile is separated by at least 1 in. from adjacent piles, and from top and walls of chamber
Incubate at 35° ± 0.5° C for 24 ± 2 hr, or
At 20° ± 0.5° C for 48 ± 3 hr
Any deviation stated in report
For shellfish incubate 48 ± 3 hr at 35° C

65. Counting
Record count observed on 1 ml sample with less than 30 colonies
Otherwise count only plates with between 30 and 300 colonies
Count colonies with approved counting aids
Record only two significant figures
Raise second digit from left by 1 when third digit is 5 or more
Record as "standard plate count at 35° C (or 20° C)"

DIFFERENTIAL PROCEDURES

66. Elevated Temperature Tests Natural bathing waters
~~Applied to positive presumptive or coliform colony~~ MF test
Inoculate fermentation tube of EC medium (3 mm loop)
Placed in water bath within 30 min
Hold at 44.5° ± 0.5° C for 24 hr M-FC Difco #516566
Gas production is positive test (indicating fecal origin)
Absence of gas is negative reaction (non-fecal origin)
Used only as confirmatory test

67. Differential Tests (Tentative)
a. Indole tests
Tryptophane Broth (35° C, 24 ± 2 hr)
Satisfactory reagent (pH < 6.0)
Procedure satisfactory
b. Methyl red test
Buffered glucose broth (35° C, 5 days)
Satisfactory indicator
Procedure satisfactory
c. Voges-Proskauer test
Buffered or salt peptone glucose broth (35° C, 48 hr)
α-napthol solution fresh daily
Procedure satisfactory
d. Sodium citrate test
Koser's citrate broth (35° C, 3-4 days) or
Simmon's citrate agar (35° C, 48 hr)
Procedure satisfactory

APPENDIX G

WATER-BORNE DISEASE OCCURRENCE

Since the middle of the nineteenth century, when Dr. John Snow did his classical study on the transmission of cholera through a water supply, it has been generally recognized that disease epidemics can, and do, result from consumption of water containing pathogenic microorganisms. Diseases most commonly associated with drinking water are cholera, typhoid fever, dysentery, and infectious hepatitis. Spread of these diseases occurs most commonly when body wastes from the infected persons are ingested. While person-to-person contact is recognized as the more common method of transmission for low incidence levels currently found in this country, the potential for catastrophic epidemics transmitted by drinking water supplies which serve thousands of people remains and demands constant vigilance.

In recent years, concern has also been directed to the possible chronic diseases which may result from use of water containing certain chemicals. These potentially dangerous chemicals include heavy metals, pesticides, and other toxic industrial products. Although few clinical cases are recorded, health agency statistics are usually limited to communicable diseases and affected individuals may have unrecognized symptons. Increased reuse of water by municipal, agricultural, and industrial users indicates vigilance against chemical contamination must be maintained.

Human body wastes from infected person(s), when present in inadequately treated drinking water, have caused widespread disease in Tennessee. In 1945, an outbreak of gastroenteritis occurred in Tazewell, which was soon followed by a typhoid epidemic involving 100 cases. This tragic incident was caused by an improperly treated drinking water supply, according to Tennessee Department of Public Health reports. In 1960, ten persons living in Lyons Park subdivision in Hawkins County contacted infectious hepatitis within a two-week period. This and other epidemiological evidence indicated water-borne transmission. The drinking water supply serving this subdivision was found to violate many health protection measures. More recently, there has been at least one case of typhoid at Top of the World in Blount County and a large outbreak of unidentified infectious disease in Brentwood, both of which have been associated with drinking water supplies. Although evidence is inconclusive, investigation revealed serious deficiencies in the health protection provided by the drinking water supplies serving these victims.

While epidemiological records do not generally show widespread incidence of water-borne disease, this may actually reflect incomplete reporting, inaccurate diagnosis and the fact that much enteric illness is not treated by physicians. This has led some authorities to suggest that cases of such diseases as gastroenteritis and infectious hepatitis may actually be as many as 100 times the number reported.

Table I presents a tabulation of significant potentially water-borne diseases and a comparison of the number of cases occurring in Tennessee versus the number occurring nationwide for the past eight years. While Tennessee has approximately two per cent of the nation's population, about three per cent of the reported infectious hepatitis cases occurred in Tennessee, about three per cent of the shigellosis occurred in Tennessee, and about five per cent of the typhoid occurred in Tennessee. The data in the Table are not intended to imply that all reported cases were water-borne. It is intended, however, to point out that a portion of these cases, plus an unknown number of unreported cases, may have been water-borne. In addition, it is significant to note that body wastes from these diseased persons pose the constant threat of contaminating public drinking water with pathogenic microorganisms.

In essentially all documented cases of water-borne illness, it has been shown that definite deficiencies existed in the water supply systems during the time when disease was transmitted. Furthermore, these deficiencies were either unrecognized because of inadequate surveillance for public health hazards, or were recognized but not remedied due to ineffective persuasion or enforcement by health officials. Deficiencies similar to those believed responsible for epidemics still are found in the water supplies of Tennessee. The requisites for repetition of the tragic epidemics of the past, namely deficient health protection of public water supplies and presence of diseased individuals in the State, are still present in Tennessee. Greater vigilance by health officials and the water supply industry is indicated in order to minimize risk from drinking water supplies.

TABLE I

INCIDENCE OF WATER-BORNE DISEASE

Year	Amebiasis	Hepatitis	Salmonellosis	Shigellosis	Typhoid
1962					
Reported Tenn. Cases	11	2,039	124	389	30
Reported U. S. Cases	3,048	53,016	9,680	12,443	608
Percent in Tenn.	0.4	3.8	1.3	3.1	4.9
1963					
Reported Tenn. Cases	20	1,459	148	379	30
Reported U. S. Cases	2,886	42,974	15,390	13,009	566
Percent in Tenn.	0.7	3.4	1.0	2.9	5.3
1964					
Reported Tenn. Cases	36	910	220	488	21
Reported U. S. Cases	3,304	37,740	17,144	12,984	501
Percent in Tenn.	1.1	2.4	1.3	3.8	4.2
1965					
Reported Tenn. Cases	51	805	191	369	18
Reported U. S. Cases	2,768	33,856	17,161	11,027	454
Percent in Tenn.	1.8	2.4	1.1	3.3	4.0
1966					
Reported Tenn. Cases	46	1,015	229	312	20
Reported U. S. Cases	2,921	34,356	16,841	11,888	378
Percent in Tenn.	1.6	3.0	1.4	2.6	5.3
1967					
Reported Tenn. Cases	33	860	436	322	12
Reported U. S. Cases	3,157	41,367	18,120	13,474	396
Percent in Tenn.	1.1	2.1	2.4	2.4	3.0
1968					
Reported Tenn. Cases	47	1,058	313	273	20
Reported U. S. Cases	3,005	50,722	16,514	12,180	395
Percent in Tenn.	1.6	2.1	1.9	2.2	5.1
1969					
Reported Tenn. Cases	83	1,097	277	336	22
Reported U. S. Cases	2,915	54,325	18,419	11,946	364
Percent in Tenn.	2.9	2.0	1.5	2.8	1.0
TOTALS					
Reported Tenn. Cases	327	9,243	1,938	2,868	173
Reported U. S. Cases	24,004	348,356	129,269	98,951	3,662
Percent in Tenn.	1.4	2.6	1.5	2.9	4.7

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